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BRUCE NUCLEAR POWER DEVELOPMENT (BNPD) POSTOPERATIONAL AQUATIC SURVEY, YEAR III - 1981

Report No 83-96-K

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ABSTRACT

This report presents the data collected as part of the third year of postoperational aquatic studies in the nearshore area of Bruce Nuclear Power Development during April-November 1981. Inorganic and organic sendimentation were maximal at Douglas Point discharge relative to other locations sampled. Strong vertical thermal gradients existed nearshore during June, July and August and maximum vertical stratification occurred later for the Bruce GS 'A' discharge area than for other locations sampled, an effect of the thermal plume at Bruce GS 'A' discharge. Water quality parameters generally reflected the oligotrophic state of Lake Huron. Temporal shifts in attached algal species composition differed among the shoreline locations, and biomass estimates were not uniform with respect to temporal or spatial gradients reflecting the extreme variability inherent in the attached algal community. Oligochaetes dominated the benthic macroinvertebrate community, with Nais pardalis being especially prominent at Bruce GS 'A' discharge. Dipterans were often associated with the northern part of the study area from Sand Bay to Baie du Doré, while oligochaetes were prevalent in the discharge areas. The highest benthic macroinvertebrate concentration was found at Baie du Doré. The most abundant fish species occurring in samples were spottail shiner, alewife, longnose sucker, bluntnose minnow and white sucker. Larval smelt and alewife occurred more frequently at inshore (1 and 3 m depth contours) than at offshore (7 m depth contour) locations. Counts of gull nests were down slightly from 1980 levels.

job	file	date	report no.
7406634-171-492	837.321	March 29, 1983	83-96-K

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EXECUTIVE SUMMARY

BRUCE NUCLEAR POWER DEVELOPMENT (BNPD) POSTOPERATIONAL AQUATIC SURVEY, YEAR III - 1981

W.E. Carey
Biological Research Section
Chemical Research Division

The third and final year of aquatic verification studies at the Bruce Nuclear Power Development (BNPD) site was conducted at the request of Environmental Studies and Assessments Department, Design and Development Division. Physical, chemical and biological data collected during the 1981 BNPD aquatic study were analyzed in order to determine the effect of generating facilities within the BNPD complex (including Bruce GS 'A', Bruce Heavy Water Plant, and Douglas Point GS) on nearshore aquatic biota. The Bruce GS 'B' location was not sampled during this survey since it was included in a separate study. A summary report covering the three years of postoperational aquatic studies will follow this report.

The rate of deposition of inorganic and organic material during May to August was similar at most locations sampled except for Bruce GS 'A' discharge, Gunn Point and Douglas Point discharge. Organic sedimentation was disproportionately greater at Bruce GS 'A' discharge (7 m depth) and both Douglas Point discharge and Gunn Point had higher inorganic and organic sedimentation rates than other locations. Mean daily water temperatures were normally higher in Bruce GS 'A' discharge than in Baie du Doré throughout the year.

Vertical temperature stratification, an effect of the heated surface plume at the 7 m depth contour of Bruce GS 'A' discharge, persisted until the end of October, when isothermal conditions existed at Sand Bay, MacPherson Bay and Bruce GS 'A' discharge 12 m depth contours.

Water quality parameters displayed greater temporal rather than spatial variability, with peaks of nutrient parameters (soluble phosphorous, nitrogen and silica) observed in May or June.

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Levels of water quality parameters reflected the oligotrophic condition of Lake Huron.

Attached algal taxonomic composition demonstrated considerable temporal and spatial variability. Taxa occurring at the shoreline were not unique to any particular sampling transect. Similarly heterogeneity existed for attached algal biomass, with no clear spatial or temporal pattern evident.

Benthic macroinvertebrate collections were dominated numerically by the oligochaete Nais pardalis. There was a tendency for benthic assemblages containing large proportions of dipterans and amphipods to occur at the northern end of the sampling area (Sand Bay to Baie du Doré), while benthic assemblages comprised of large proportions of oligochaetes occurred more frequently at the southern end (Bruce GS 'A' discharge to Gunn Point). Elevated temperatures and higher current activity in the vicinity of discharge areas may be enhancing the proliferation of oligochaetes (particularly Naididae) in the nearshore zone off BNPD.

The most abundant forage fish species captured at BNPD were spottail shiner (Notropis hudsonius), alewife (Alosa pseudoharengus) and bluntnose minnow (Pimephales notatus). Fish species of commercial or recreational importance collectively accounted for about 4% of the overall catch. Alewife and longnose sucker exhibited characteristic peaks of abundance corresponding to spring spawning periods. Bruce GS 'A' discharge and MacPherson Bay were associated with the lowest overall fish catches, while Baie du Doré recorded the largest fish catch. The only fish species which had relatively high abundance at Bruce GS 'A' discharge compared to other locations sampled were spotfin shiner (Notropis spilopterus), channel catfish (Ictalurus punctatus) and yellow pickerel (Stizostedion vitreum). These species have a specific requirement for substantial current activity. The catch of round whitefish (Prosopium cylindraceum) was rather evenly distributed along the BNPD shoreline area. Large catches of smelt (Osmerus mordax) and alewife larvae were made inshore (1 m and 3 m depths) near discharge locations and at Baie du Doré. Larval smelt entrainment estimates ranged from 5.0×10^3 larvae per day at Douglas Point GS in June to 2.7×10^6 larvae per day at Bruce GS 'A' in June.

The colony of nesting gulls at the Bruce GS 'A' site appeared to decrease in size, as reflected in a drop in the number of gull nests from 6,096 in 1980 to 4,933 in 1981.

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BRUCE NUCLEAR POWER DEVELOPMENT (BNPD)
POSTOPERATIONAL AQUATIC SURVEY, YEAR III - 1981

1.0 INTRODUCTION

The third and final year of postoperational aquatic environmental studies was conducted at the Bruce Nuclear Power Development (BNPD) site during April-November 1981 at the request of Environmental Studies and Assessments Department of Design and Development Division. This report analyzes the physical, chemical and biological data obtained during 1981. The pre- and postoperational program has as its objective the determination of the effect of generating station facilities on the aquatic biota in the nearshore zone of Lake Huron adjacent to the BNPD site. A separate postoperational aquatic study was also conducted at Bruce Heavy Water Plant (BHWP) during May-October, 1981 (Ontario Hydro Research Division Report No 82-512-K).

The study area is located on the eastern shore of Lake Huron and encompasses a 14-km stretch of shoreline from Sand Bay in the north to Gunn Point in the south (Figure 1). The 1981 survey did not involve Bruce GS 'B' since it was the subject of another study, but included Bruce Generating Station (GS) 'A', Bruce Heavy Water Plant (BHWP) and Douglas Point Generation Station (GS), which have maximum volume discharges of 170, 34 and 14 m^3/s, respectively (Ontario Hydro Research Division Report No 82-182-K). All three stations were operational during the 1981 study. The maximum effluent temperature (32.2°C) was not exceeded at any station and the ΔT values (11.1°C for BHWP and Bruce GS 'A', and 11.7°C for Douglas Point GS) were not exceeded during the 1981 aquatic survey (Ontario Hydro Nuclear Generation Division Report RMEP IR-07000-4). Construction activities continued at Bruce GS 'B', located at the southern extremity of

BNPD. The sampling effort expended in this study was in accordance with discussions between representatives of Ontario Ministries of Natural Resources and the Environment, and Ontario Hydro (Minutes of Meeting; June 1981-NK21-07015T5).

2.0 METHODS

2.1 Sampling Schedule

The sampling schedule for physical, chemical and biological characteristics is summarized in Table I.

2.2 Physical Characteristics

2.2.1 Water Temperature and Transparency

Water temperature profiles and secchi disc readings were taken monthly from May to November at the nine sampling locations indicated in Figure 1. Temperatures were recorded at the surface and at 1 m intervals to the lake bottom. Daily mean temperatures were derived from Hydraulic Studies and Development Department's continuous temperature records obtained at two stations: at a depth of 2.0 m near the end of Bruce GS 'A' outfall and at a depth of 2.5 m along the 3.0 m depth contour, approximately 1.0 km southwest of the University of Toronto's Institute for Environmental Studies boat dock in Baie du Doré (Figure 1).

2.2.2 Sedimentation

Sediment tubes consisting of four 63 cm high by 5 cm inside diameter PVC tubes in a metal frame were set at the 3, 7 and 12 m depths along nine transects (Figure 1). Traps were set for two-three month periods, May to August and August to November. Traps were retrieved and reset in August by SCUBA divers who capped the tubes prior to recovery. Samples were frozen for later analysis. After a one hour settling period, the contents of the tubes were oven dried at 105°C to constant weight, then ashed for two hours at 525°C. The August to November samples were considered invalid, since many tubes were overturned or contained large stones.

Results were expressed as amount of organic and inorganic material trapped in tubes.

Rates of sedimentation were expressed as $g/cm^2/month$.

2.3 Water Chemistry

Surface water samples were collected monthly from May to November with an 8 L PVC Van Dorn bottle at the Bruce GS 'A'

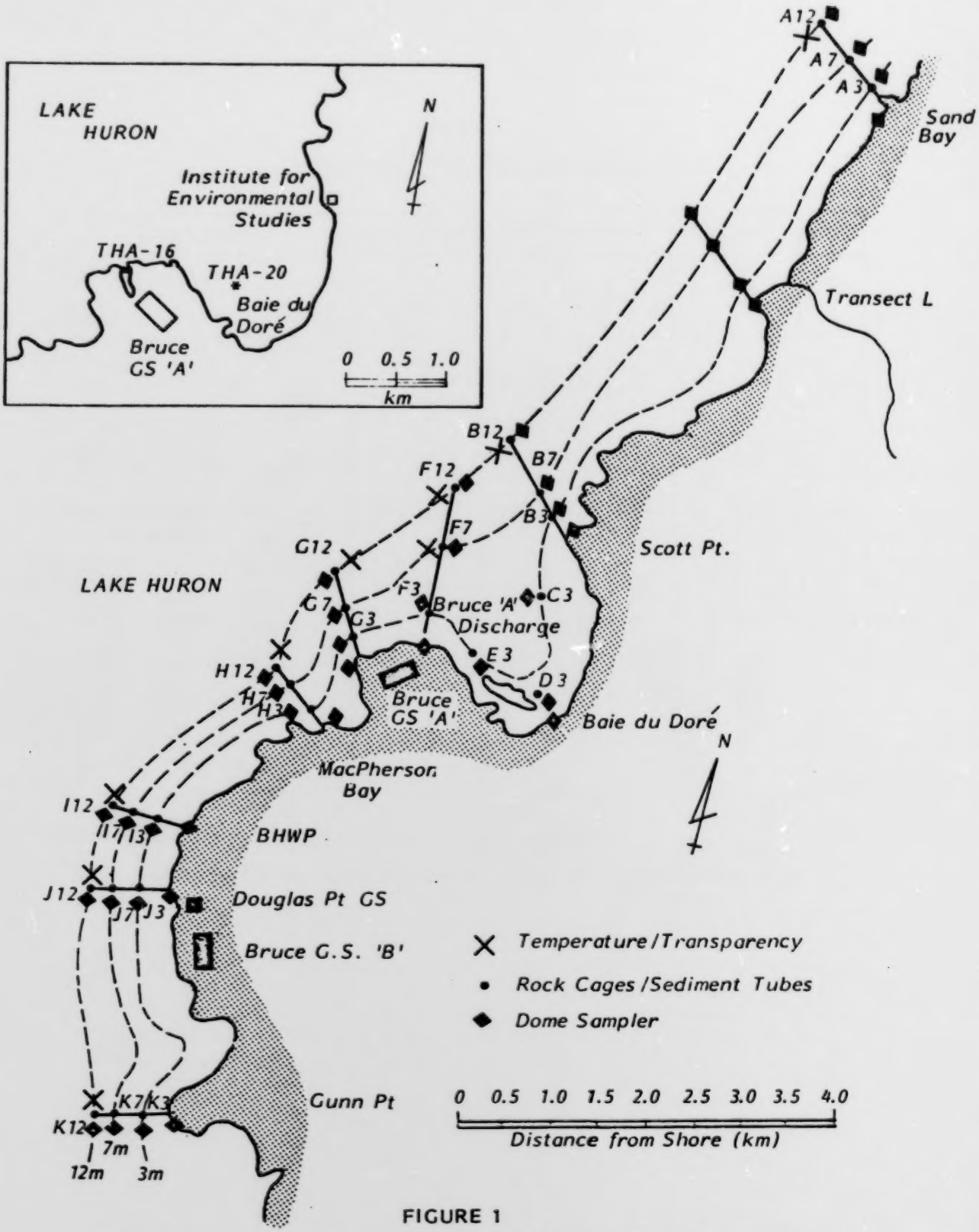

FIGURE 1

SAMPLING TRANSECTS AND SPAR LOCATIONS FOR ZOOBENTHOS SAMPLING, SEDIMENT COLLECTION, AND TEMPERATURE/ TRANSPARENCY RECORDING BNPD - 1981

Inset shows continuous temperature recording stations

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TABLE I

BNPD 1981 SAMPLING SCHEDULE

Component	April	May	June	July	Aug	Sept	Oct	Nov
Sedimentation					X			X
Temperature & Transparency		X	X	X	X	X	X	O
Water Chemistry		X	X	X	X	X	O	X
Attached Algae:								
Basic Sampling		X	X	X	X	X	X	
Map of Percent Cover					O			
Phytoplankton and Zooplankton (Grid)		X	X(X)	X	X(X)	X	X(X)	
Zoobenthos:								
Rock Cages			X	X	X	O	X	
Vacuum Domes					X			
Ichthyoplankton	XX	XX	XX	XX	XX			
Adult & Juvenile Fish		X	X	X	X	X	X	
Nesting Gulls		X						

X = conducted as scheduled

O = incomplete or no sample due to poor weather conditions

intake forebay, Bruce GS 'A' Discharge (3 m), Sand Bay (12 m) and Gunn Point (12 m) in accordance with procedures set out in Ontario Hydro Research Division Report No 78-285-K. Analyses were performed for the following water quality parameters: pH, calcium (Ca), magnesium (Mg), chlorophyll a, specific conductance, total Kjeldahl nitrogen, soluble nitrogen, particulate nitrogen, nitrate nitrogen, nitrite nitrogen, total phosphorous, soluble phosphorous, particulate phosphorous, orthophosphorous, total silica, soluble silica, suspended and dissolved solids (both at 105°C and 550°C), and turbidity.

2.4 Biological Characteristics

2.4.1 Attached Algae

Attached algae were sampled in triplicate from May to October from natural substrates at ten shoreline locations. Additionally six deeper locations were sampled bimonthly commencing in June (Table II). Samples were scraped from 25 cm^2 of substrate and preserved in 5% formalin. Samples were identified then dried at 105°C to constant weight and ashed at 525°C for one hour. Results were expressed as per cent species composition, dry weight and ash free dry weight and analyzed with standard statistical techniques. Attached algae per cent cover was mapped in August from Sand Bay to Scott Point, with severe weather conditions preventing completion to Gunn Point. Results of the mapping effort will not be presented in this report, however a composite map will be included in a three-year summary report.

2.4.2 Benthic Macroinvertebrates

Rock cages were used to sample zoobenthos monthly from May to October. Rough weather prevented sampling during September, and part of June, August and October. Ten cages were placed at each sampling location (Figure 1) in May. Two cages were retrieved monthly from June to October by SCUBA divers. Cages were bagged underwater before retrieval to reduce loss of organisms from samples, which were subsequently washed through a 60 mesh (325 µm) screen and preserved in 5% formalin. In addition to rock cage samples a 40 point grid (Figure 1) was sampled by SCUBA divers in August using a 15.2 cm vacuum dome sampler. Triplicate samples were scraped from bottom substrate inside the dome then vacuumed into 64 µm mesh bags, returned to the surface, transferred into sample bottles, and preserved in 5% formalin. Benthic organisms were sorted, identified and counted. Ancillary information collected on each sampling date included substrate type, per cent algal cover, and bottom temperature and dissolved oxygen (rock cages), and bottom temperature, secchi depth, substrate type and per cent algal

TABLE II

ATTACHED ALGAE AND ICHTHYOPLANKTON SAMPLING LOCATIONS BNPD-1981

Location	Spar No	Shore	1 m	3 m	7 m	12 m
Sand Bay	A	X		X(*)		
	L	X				
	M	X				
Scott Point	B	X	•	•	•	
Baie du Doré	C	X	•	•		
	D		•	X(*)•		
	E		•	•		
Bruce A Discharge	F	X(5*)	•	•	•	
Bruce A Intake	G		•	•	•	
MacPherson Bay	H	X				
BHWP Discharge	I	X	•	•	•	
Douglas Point Discharge	J	X(2*)	•	•	•	
Gunn Point	K	X	X(*)	X(*)	X(*)	X(*)
Bruce A Forebay BHWP Forebay Douglas Point Forebay	Ichthyoplankton Sampling Only					

X Attached Algae Locations
• Ichthyoplankton Locations
* June, August and October only

Note: The numbers 5 and 2 refer to the number of shore sites sampled within Bruce GS 'A' discharge and Douglas Point discharge, respectively.

cover (vacuum domes). Statistical analysis was performed where applicable.

2.4.3 Ichthyoplankton

Larval fish were collected biweekly at the forebays of Bruce GS 'A', Douglas Point GS, and BHWP, and twenty-one lake locations (Table II). The forebays were sampled from April to August, while the 21 lake locations were sampled from mid May to August. All locations were sampled at night except for daytime sampling in the three forebays during April. Sampling in the forebays was conducted by suspending two 50 cm round conical nets (363 µm mesh) in high current areas (approximately 2.0 m depth) for five minutes. The lake sampling was conducted by suspending the two nets in front of a 6.4 m boat and pushing them along the lake surface at ≈1 m/sec for five minutes. Each duplicate tow was estimated to sample about 120 m^3 of lakewater.

Samples were preserved in 5% formalin, sorted and identified. Results were expressed as species density (number per 1000 m^3 of lake water) and distribution patterns were examined. Larval fish entrainment at the Bruce GS 'A', BHWP, and Douglas Point forebays were estimated as the mean numbers of larvae entrained per day during May, June and July.

2.4.4 Juvenile and Adult Fish

Two beach seine hauls were made during June, July, August and October at eight shoreline locations (Figure 2) at dusk. Samples were preserved in 5% formalin, sorted and identified. Beach seine hauls were not attempted in May or September due to poor weather condtions.

Adult fish were sampled monthly from May to October at each of eight locations (Figure 2) utilizing experimental gill nets with mesh sizes of 3.8, 5.1, 6.4, 7.6, 8.9, 10.2, 11.4 and 12.7 cm. All gill net fishing at Douglas Point discharge and Gunn Point transects, which were common to BNPD and Bruce GS 'B' 1981 aquatic surveys, involved gangs of nets with an additional mesh size of 2.5 cm. Other locations where 2.5 cm mesh was employed were at Sand Bay in May and June, Scott Point in July, Bruce GS 'A' discharge in August, BHWP discharge in July and Baie du Doré in May. However, the calculation of gill net catch per unit effort was performed only for catches obtained from mesh sizes 3.8 cm through 12.7 cm in order to be consistent with the 1979 BNPD aquatic survey. Gill nets were set for one 24 h period, with a single gill net gang used at each sampling location. Paired 1.2 m trap nets were fished for two consecutive 24 h periods. Each fish catch was speciated and counted, and a random sample of up to 20 fish per selected species was measured

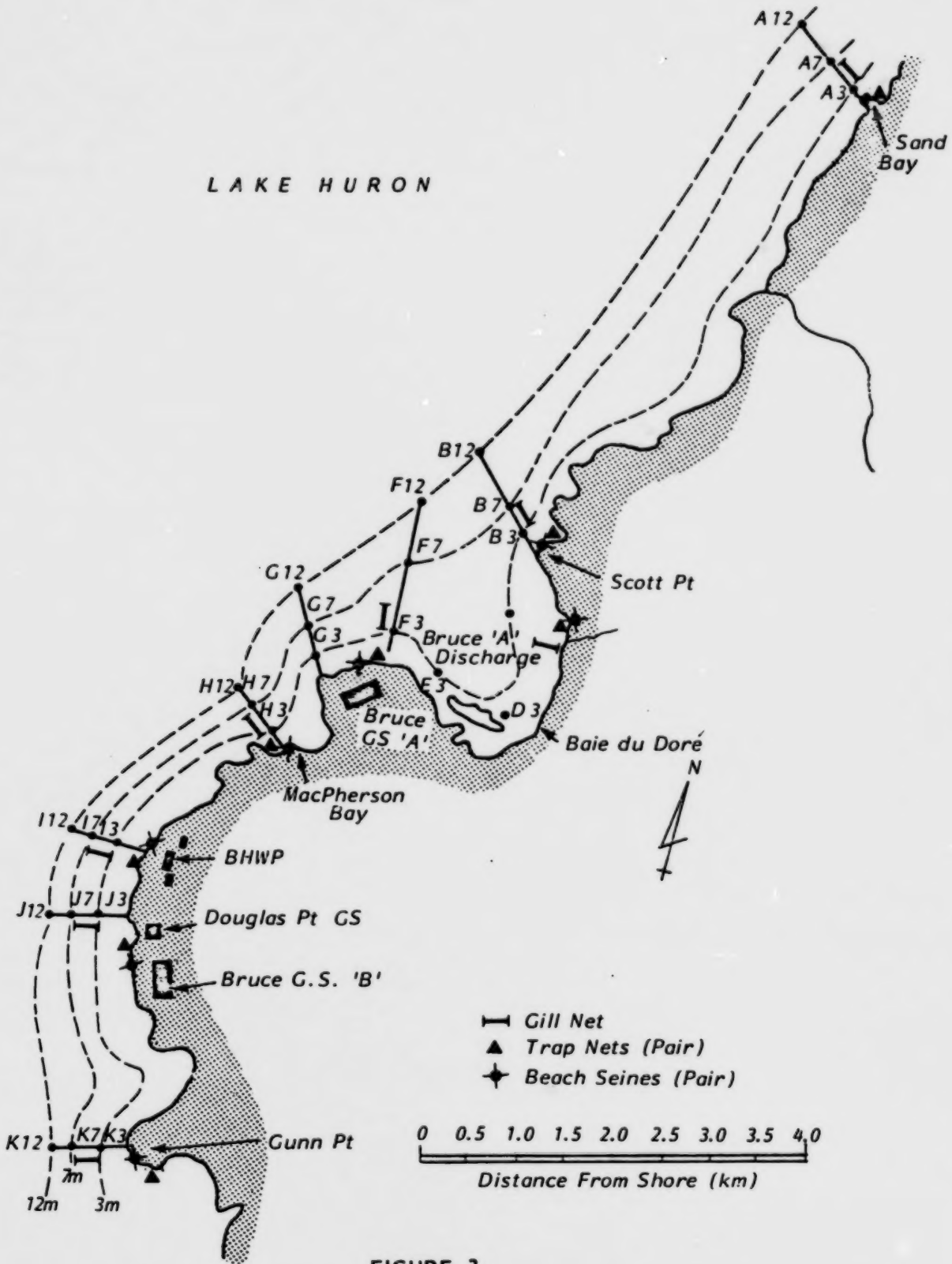

FIGURE 2

FISHING LOCATIONS BNPD 1981

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(fork length), weighed and aged. Fish stomach analysis was attempted for selected fish species including brown bullhead, longnose sucker, white sucker, rock bass, yellow perch, smallmouth bass and rainbow trout. Fish were not sampled for stomach contents during their spawning season, and most samples were collected in midsummer. However the fish stomach survey was limited by the discovery of deteriorating fish in some nets in July and August. For each species, results were expressed as the per cent biomass of food items found, and the per cent frequency of major invertebrate groups ingested.

2.4.5 Nesting Gulls

A survey was conducted of the nesting gull colony south of the Bruce GS 'A' discharge in May. All nests were counted, distinguishing between Ring-billed and Herring Gull nests. Results were expressed as number of nests per species and average number of eggs per nest.

3.0 RESULTS AND DISCUSSION

3.1 Physical Characteristics

3.1.1 Water Temperature and Transparency

Mean Daily Temperatures

Figure 3 depicts the mean daily water temperatures recorded at two spar locations near the BNPD site:

(i) THA18 at a depth of 2.0 m in Bruce GS 'A' discharge and,

(ii) THA20 at a depth of 2.5 m in Baie du Doré.

It is evident that, with few exceptions, water temperatures observed in Bruce GS 'A' discharge were higher than those recorded in Baie du Doré. The maximum daily mean temperature was 29.7°C in Bruce GS 'A' discharge and 25.7°C in Baie du Doré, registered on August 13 and 24, respectively.

Water temperature fluctuations at the Bruce GS 'A' discharge (range 8.3-12.6°C) during the period January through March were minor compared to the wide range of temperatures which occurred during the same period in Baie du Doré (0.6-10.3°C).

Past records show that frequent major upwellings sometimes occur during July, August and September at the BNPD site (Ontario Hydro Research Division Report Nos 74-449-H, 76-343-K, 82-107-K and 82-182-K). Major upwellings were not apparent in 1981, however water temperatures were nevertheless subject to rapid changes during the summer months, with the lowest mean daily

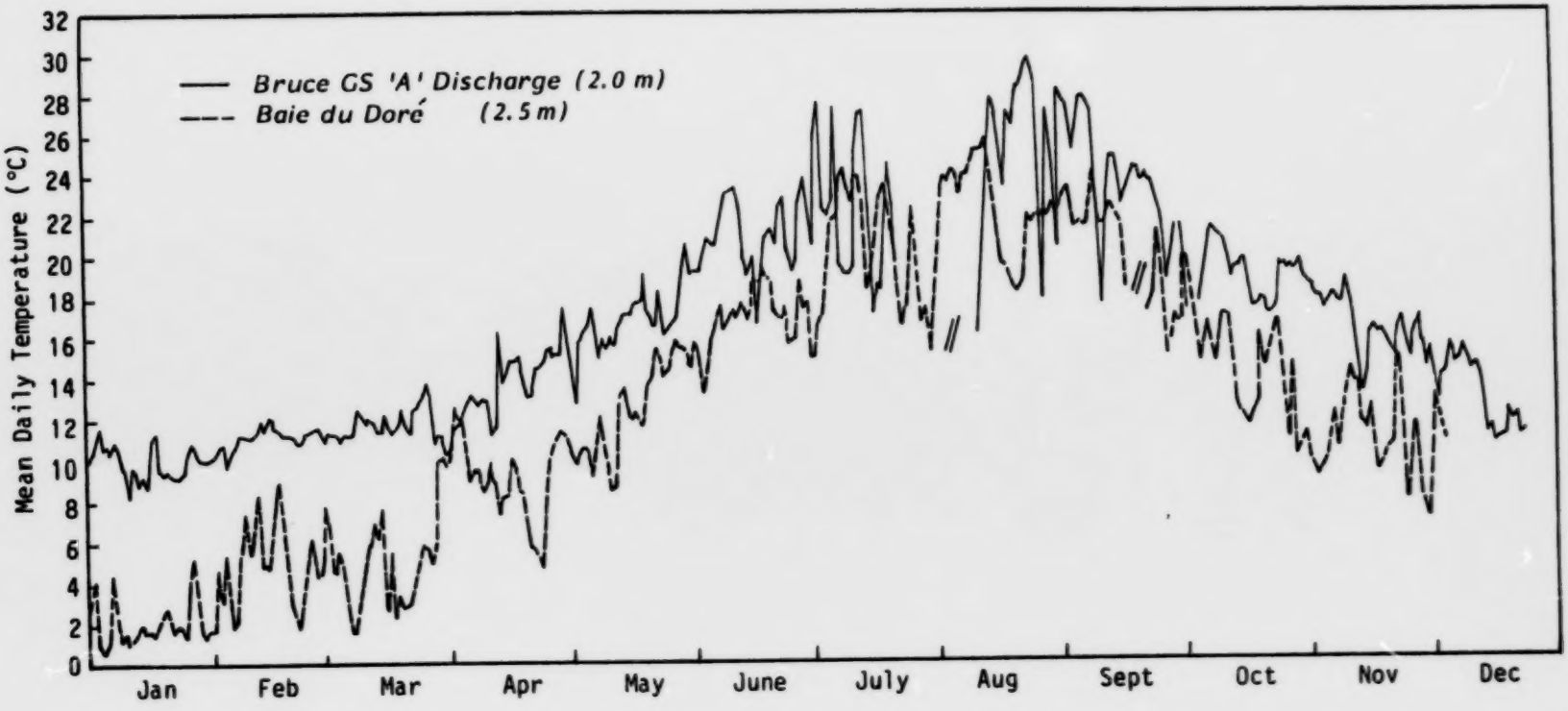

FIGURE 3

MEAN DAILY TEMPERATURES RECORDED AT BRUCE GS'A' DISCHARGE (2.0 m DEPTH AT SPAR THA 18) AND BAIE DU DORÉ (2.5 m DEPTH AT SPAR THA 20) DURING 1981 - BNPD, 1981

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temperature (15°C) recorded at Baie du Doré (Figure 3). The area influenced by the discharge represented a more thermally stable environment during winter and spring than the Baie du Doré area. This observation is consistent with the fact that winter currents are weak near BNPD, limiting the influence of the Bruce GS 'A' discharge on Baie du Doré during winter (R. Metcalfe, personal communication). The midsummer temperature regime was less stable in Bruce GS 'A' discharge and resembled that of Baie du Doré (Figure 3).

Vertical Temperature Profiles

Vertical temperature profiles for the 12 m isobaths of Bruce GS 'A' discharge, Sand Bay and MacPherson Bay, and the 7 m isobath of Bruce GS 'A' discharge, are presented in Figures 4 and 5. Complete temperature profile data are contained in Appendix 1.

Weak thermal stratification was observed at Sand Bay on May 28, 1981, with temperatures ranging from 9.3°C at the surface to 6.6°C at the 10 m depth. However on June 25, a nearly isothermal water column existed, since the surface and bottom temperatures only varied by 1.5°C (Figure 4). A strong thermal gradient was evident on July 29, and stratification had occurred in the first few meters of the water column by August 20. Isothermal conditions were restored on September 30 and October 30, when the water temperature was 15.0°C and 8.2°C, respectively.

Thermal conditions at MacPherson Bay differed markedly from those at Sand Bay. Strong thermal gradients existed on June 25 and August 20 with vertical stratification occurring on June 25 and to a lesser extent on August 20 (Figure 4). The thermal gradient which was evident on June 25 had temperatures ranging from 9.5°C at the lake bottom to 18.5°C at the surface. The water column was isothermal on September 30 and October 30, with temperatures of 15.5°C and 9.4°C, respectively.

At the 7 m depth contour location of Bruce GS 'A' discharge, strong thermal gradients occurred on all sampling dates (Figure 5). Maximal vertical stratification occurred on September 30, when surface and bottom (7 m) temperatures were 21.4°C and 15.2°C respectively. Between 1 and 2 m of depth, the water temperature dropped 4°C (Figure 5). The lowest surface and bottom temperatures in the May 28 to October 30 period were recorded on July 29 (10.8°C and 7.2°C, respectively), and were probably associated with a sharp drop in lake temperature which occurred near the end of July (Figure 3). The strong thermal gradients observed at this location are considered to be a function of the warm surface plume emanating from Bruce 'A' discharge. The observation that vertical thermal stratification

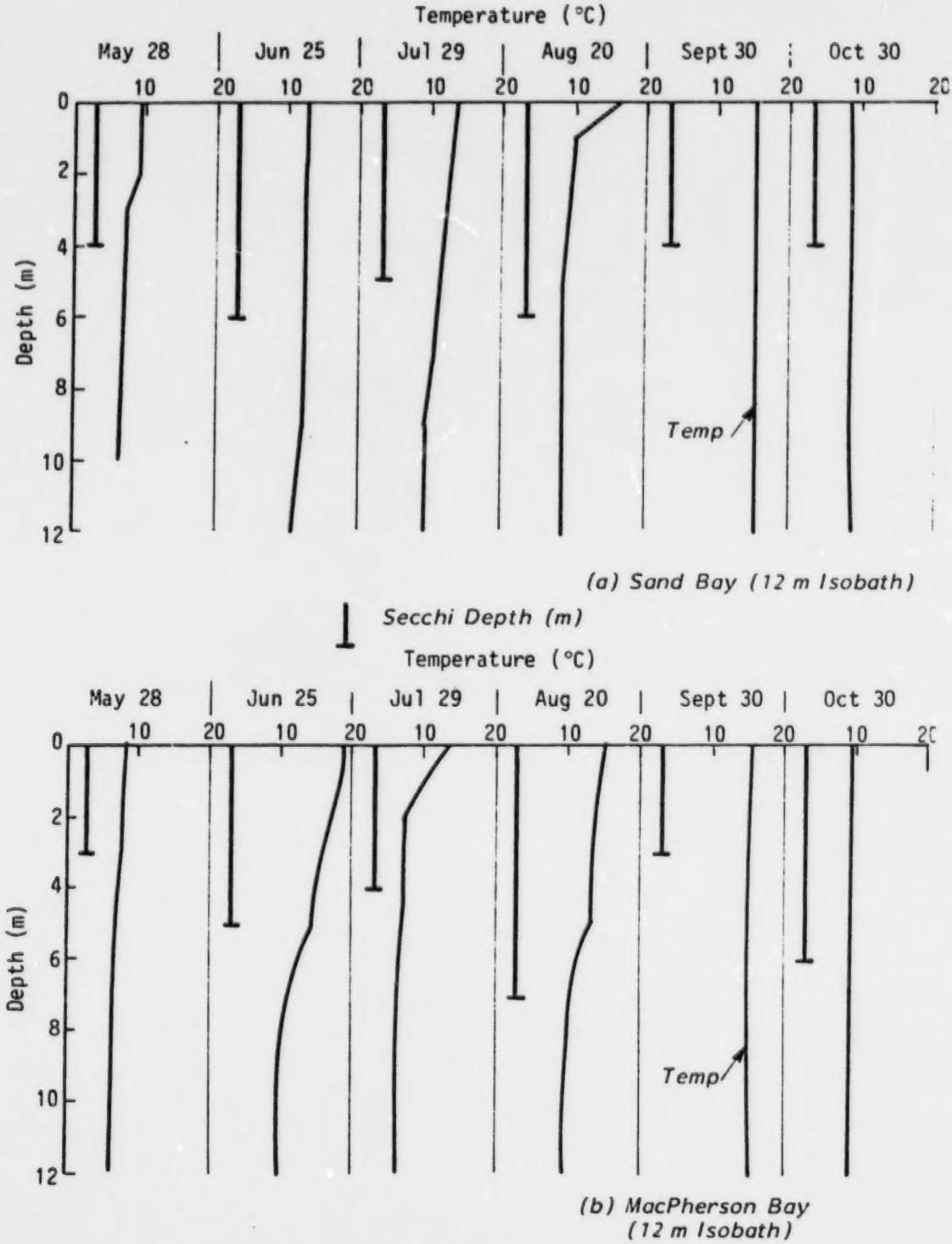

FIGURE 4

SECCHI DISC TRANSPARENCY DEPTHS AND VERTICAL TEMPERATURE PROFILES AT THE 12 m ISOBATH FOR a) SAND BAY AND b) MACPHERSON BAY - BNPD, 1981

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persisted later in the year at Bruce 'A' discharge (7 m isobath) than at other locations sampled is further evidence of the effect of the thermal plume.

The thermal structure at the 12 m isobath of Bruce GS 'A' discharge resembled that at the 12 m isobath of MacPherson Bay. A weak thermal gradient occurred on May 28 and was followed by stronger thermal gradients on June 25, July 29 and August 20. Vertical stratification was evident on the latter three occasions, being particularly intense on July 29 when the water temperature dropped from 11.0°C to 8.4°C between 4 m and 5 m of depth (Figure 5). Isothermal conditions were recorded on September 30 and October 30, as was observed for both Sand Bay and MacPherson Bay locations. Therefore the thermal structure appeared to be less influenced by the plume at the 12 m depth contour.

Water Transparency

Secchi depths were recorded along with vertical temperature profiles and are presented in Figures 4 and 5, and Appendix 1. In general, the pattern of monthly secchi depth was similar at all locations sampled. Minimum water transparency occurred on September 30 at the 7 m and 12 m depth contours of Bruce GS 'A' discharge, as indicated by a secchi depth of 2 m (Figure 5). Maximum secchi depth occurred on August 20 (7 m), indicating rather clear waters. Water clarity was slightly greater at the 12 m depth contour of Sand Bay where the minimum secchi depth was 4 m (Figure 4). The minimum and maximum secchi depth at MacPherson Bay were 3 m and 7 m, and occurred on May 28, August 20 and July 29, respectively.

3.1.2 Sedimentation

Mean inorganic sedimentation rates declined with distance from shore, with means of 0.829 and 0.576 g/cm^2/month at the 3 m and 12 m depth contours respectively (Figure 6, Appendix 2). At all depth contours sampled, the rate of sedimentation of inorganic material was highest (near 3.0 g/cm^2/month) at Douglas Point discharge. The Gunn Point location was associated with the second highest inorganic sedimentation rate, especially at the 3 m and 7 m depth contours. Lower inorganic sedimentation rates were observed at other locations (Figure 6). Construction activities at the Bruce GS 'B' site during 1981 likely contributed to the high rates of inorganic sedimentation which occurred at Douglas Point discharge and Gunn Point.

Historic (1972-1975, 1977-1979) lake current data from the nearshore zone off Bruce GS 'B' show that the predominant summer current direction is northerly, with current speeds averaging

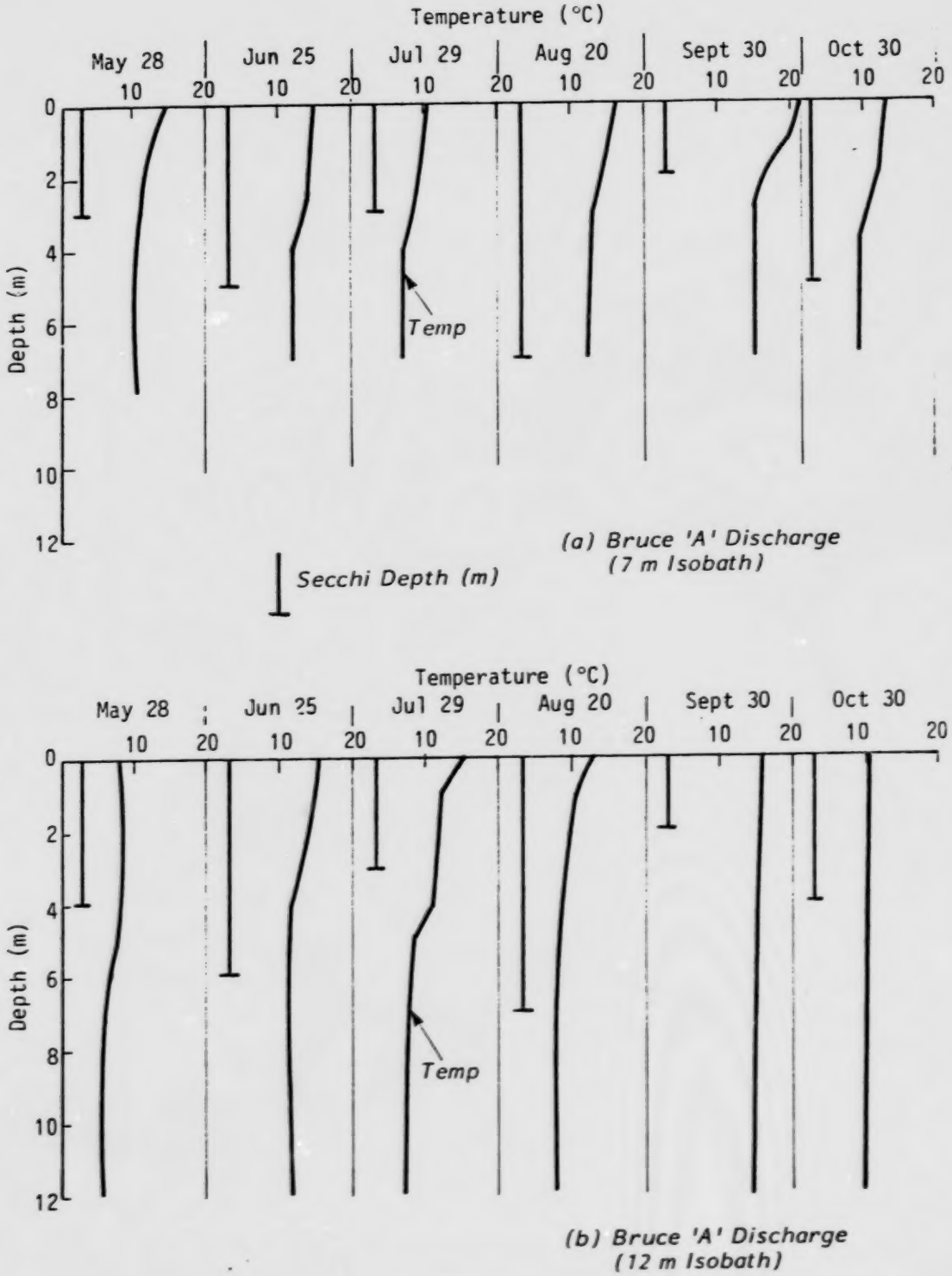

FIGURE 5

SECCHI DISC TRANSPARENCY DEPTHS AND VERTICAL TEMPERATURE PROFILES AT THE a) 7 m AND b) 12 m ISOBATHS FOR BRUCE 'A' DISCHARGE - BNPD, 1981

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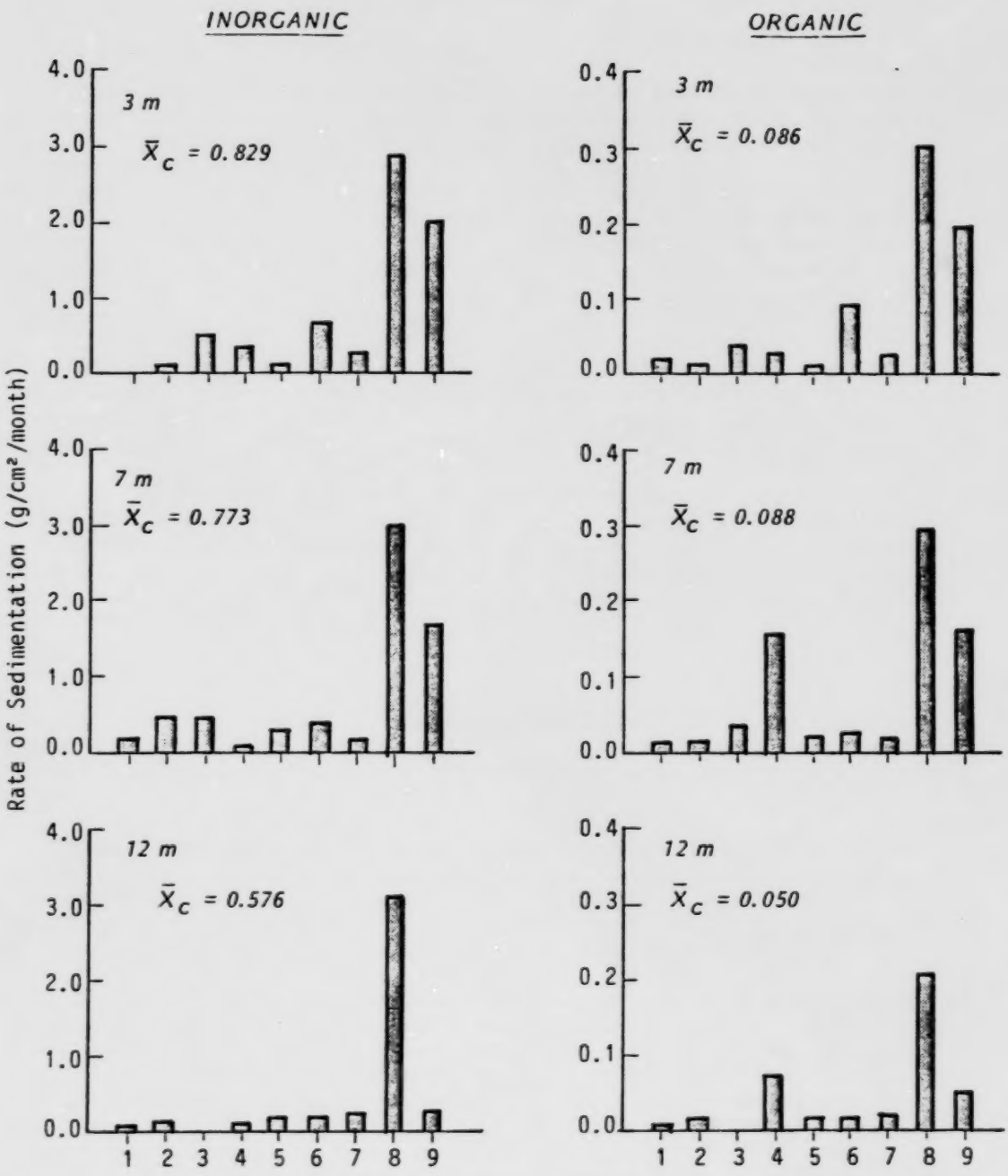

1. Sand Bay
2. Scott Point
3. Baie du Dore
4. Bruce 'A' Discharge
5. Bruce 'A' Intake
6. MacPherson Bay
7. BHWP Discharge
8. Douglas Point Discharge
9. Gunn Point

$\bar{X}_c$ = Depth Contour Mean

FIGURE 6

INORGANIC AND ORGANIC SEDIMENTATION RATES
FOR THE MAY - AUGUST PERIOD BNPD - 1981

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10.5 cm/s (Ontario Hydro Hydraulic Studies and Development Report No 82393). This pattern of water movement could result in a net northward transportation of inorganic material from southerly locations such as Inverhuron Bay, where substrate consists primarily of sand and silt (Ontario Hydro Research Division Report No 82-205-K). The Douglas Point discharge may act as a partial barrier to further northerly transport of suspended material, by interacting with nearshore (3 m or less) northerly currents and deflecting some suspended material in an offshore direction (R. Metcalfe, personal communication).

The pattern of distribution of organic sedimentation rates for the May to August period was similar to that observed for inorganic sedimentation rates with one notable difference. Organic sedimentation rates were relatively high in Bruce GS 'A' discharge at the 7 m and 12 m depth contours (0.159 and 0.075 g/cm^2/month, respectively) compared with other locations (with the exception of Douglas Point discharge and Gunn Point). Mean organic sedimentation rate was highest at the 7 m depth contour. There are insufficient data to determine why organic sedimentation was high at Bruce 'A' discharge, Douglas Point discharge and Gunn Point.

3.2 Water Chemistry

The results of the water chemistry analyses are presented in Tables III and IV. In general the water quality parameters tested had values which are characteristic of oligotrophic Lake Huron.

It is well known that the biological productivity of a lake system is determined largely by the availability of nutrient parameters such as phosphorous and nitrogen. Phosphorous is considered to be the nutritional component which most commonly limits lake primary productivity (Wetzel, 1975).

At the four BNPD locations sampled, total phosphorous levels had an overall seasonal range of 5 µg/L to 19 µg/L (Tables III and IV). Peak total phosphorous concentrations occurred on June 17 at the four locations although values at Bruce GS 'A' forebay and Gunn Point (19 µg/L) were higher than those at Bruce 'A' discharge and Sand Bay (15 µg/L). An overall seasonal average total phosphorous concentration of 10 µg/L is a firm indication of the oligotrophic status of Lake Huron in the vicinity of BNPD (Kwiatkowski, 1980). Figure 7 shows that soluble phosphorous was present in measurable quantities mainly during late spring (June 17) and early fall (September 30) periods. The spring soluble phosphorous peaks were greater at Gunn Point and Bruce GS 'A' forebay locations (18 µg/L) than at Bruce GS 'A' discharge (9 µg/L) and Sand Bay (14 µg/L) locations, resulting

TABLE III

SAND BAY AND GUNN POINT
WATER CHEMISTRY ANALYSIS - 9NPD, 1981

Location: Sand Bay Parameter	May 13	June 17	July 22	Aug 27	Sept 30	Nov 10
pH	8.2	8.0	7.8	8.2	8.1	7.9
Conductivity (mS/m)	20.0	19.0	17.0	18.6	18.0	18.0
Turbidity (NTU)	1.5	1.0	1.0	0.4	1.2	2.5
Suspended solids at 105°C (mg/L)	3.6	2.3	<1.0	<1.0	1.2	5.6
Suspended solids at 550°C (mg/L)	2.4	<0.5	<1.0	<1.0	1.2	4.0
Dissolved solids at 105°C (mg/L)	132	110	129	142	116	99
Dissolved solids at 550°C (mg/L	113	87	100	108	80	90
Total phosphorous (ug/L)	13	15	6	9	9	6
Soluble phosphorous (ug/L)	<5	14	<5	5	9	<5
Particulate phosphorous (ug/L)	8	1	1	4	0	1
Filtrable orthophosphorous (ug/L)	<5	10	6	<5	9	<5
Total Kjeldanl nitrogen (mg/L)	1.00	0.90	0.20	0.30	0.17	0.14
Soluble nitrogen (mg/L)	1.00	0.61	0.03	0.30	0.13	0.12
Particulate nitrogen (mg/L)	0.00	0.32	0.17	0.00	0.04	0.02
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate (mg/L)	1.8	1.1	1.0	1.1	1.1	1.2
Total silica (mg/L)	1.63	1.49	1.08	1.48	1.60	1.39
Soluble silica (mg/L)	1.08	1.37	0.79	1.07	1.18	1.09
Calcium (mg/L)	30	26.3	27.0	27.0	26.0	25.0
Magnesium (mg/L)	7.5	7.0	7.5	7.1	6.8	7.1
Chlorophyll a (ug/L)	<0.5	1.7	<0.5	<0.5	1.6	2.2

Location: Gunn Point Parameter	May 13	June 17	July 22	Aug 27	Sept 30	Nov 10
pH	8.1	8.2	7.9	8.3	8.1	7.9
Conductivity (mS/m)	20.0	18.1	18.5	19.0	19.0	18.0
Turbidity (NTU)	1.3	1.2	1.2	0.4	1.5	1.9
Suspended solids at 105°C (mg/L)	2.6	2.0	2.0	2.7	<1.0	3.6
Suspended solids at 550°C (mg/L)	1.4	<0.5	1.8	<1.0	<1.0	2.8
Dissolved solids at 105°C (mg/L)	122	110	122	130	118	121
Dissolved solids at 550°C (mg/L)	95	79	102	96	84	105
Total phosphorous (ug/L)	14	19	6	7	7	5
Soluble phosphorous (ug/L)	<5	18	6	<5	7	<5
Particulate phosphorous (ug/L)	9	1	0	2	0	0
Filtrable orthophosphorous (ug/L)	<5	9	<5	<5	8	<5
Total Kjeldanl nitrogen (mg/L)	0.90	0.92		0.25	0.19	0.16
Soluble nitrogen (mg/L)	0.80	0.73		0.24	0.15	0.14
Particulate nitrogen (mg/L)	0	0.19		0.01	0.04	0.02
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate (mg/L)	2.00	1.20	0.68	1.10	1.10	1.20
Total silica (mg/L)	1.62	1.36	1.67	1.39	1.37	1.84
Soluble silica (mg/L)	1.23	0.64	1.13	0.94	1.07	0.73
Calcium (mg/L)	28.0	26.9	25.1	27.0	27.0	25.0
Magnesium (mg/L)	7.0	7.1	6.9	7.2	6.9	7.0
Chlorophyll a (ug/L)	<0.5	1.8	0.9	<0.5	2.0	1.3

TABLE IV

BRUCE GS 'A' DISCHARGE AND FOREBAY

WATER CHEMISTRY ANALYSIS - BNPD, 1981

Location: Bruce GS 'A' Discharge Parameter	May 13	June 17	July 22	Aug 27	Sept 30	Nov 10
pH	8.1	7.9	7.8	8.0	8.2	7.8
Conductivity (mS/m)	20.0	18.5	18.5	19.1	19.0	18.0
Turbidity (NTU)	1.5	1.1	1.4	0.4	1.8	1.5
Suspended solids at 105°C (mg/L)	2.6	1.5	<1.0	<1.0	1.2	2.0
Suspended solids at 550°C (mg/L)	1.4	<0.5	<1.0	<1.0	1.2	1.5
Dissolved solids at 105°C (mg/L)	127	110	129	140	122	102
Dissolved solids at 550°C (mg/L)	105	90	102	104	94	100
Total phosphorous (µg/L)	14	15	6	5	8	7
Soluble phosphorous (µg/L)	<5	9	<5	<5	8	5
Particulate phosphorous (µg/L)	9	6	1	0	0	2
Filtrable orthophosphorous (µg/L)	<5	8	6	<5	7	5
Total Kjeldahl nitrogen (mg/L)	0.40	0.73	0.18	0.30	0.16	0.13
Soluble nitrogen (mg/L)	0.40	0.73	0.01	0.30	0.14	0.12
Particulate nitrogen (mg/L)	0	0	0.17	0	0.02	0.01
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate (mg/L)	2.0	1.3	1.0	1.1	1.1	1.2
Total silica (mg/L)	1.62	1.52	1.87	1.52	1.63	1.03
Soluble silica (mg/L)	1.39	1.09	0.98	1.07	0.83	0.79
Calcium (mg/L)	29.0	27.0	26.9	27.0	27.0	25.0
Magnesium (mg/L)	7.3	7.1	7.4	7.0	6.9	7.0
Chlorophyll a (µg/L)	<0.5	1.6	0.5	<0.5	1.7	1.5

Location: Bruce GS 'A' ForeBay Parameter	May 13	June 17	July 22	Aug 27	Sept 30	Nov 10
pH	8.1	8.0	7.8	8.2	8.2	7.8
Conductivity (mS/m)	20.0	18.2	18.5	18.9	19.0	19.0
Turbidity (NTU)	1.5	1.1	1.0	0.4	1.5	1.5
Suspended solids at 105°C (mg/L)	1.4	1.8	1.0	1.3	2.3	2.3
Suspended solids at 550°C (mg/L)	1.4	<0.5	<1.0	<1.0	1.6	1.5
Dissolved solids at 105°C (mg/L)	126	106	126	132	104	113
Dissolved solids at 550°C (mg/L)	103	65	99	100	74	97
Total phosphorous (µg/L)	15	19	19	7	10	10
Soluble phosphorous (µg/L)	<5	18	6	<5	9	9
Particulate phosphorous (µg/L)	10	1	13	2	1	1
Filtrable orthophosphorous (µg/L)	6	16	<5	<5	9	8
Total Kjeldahl nitrogen (mg/L)	0.5		0.15	0.27	0.17	0.13
Soluble nitrogen (mg/L)	0.5	0.73	0.01	0.27	0.15	0.12
Particulate nitrogen (mg/L)	0		0.14	0	0.02	0.01
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate (mg/L)	2.0	1.3	1.3	1.1	1.1	1.3
Total silica (mg/L)	1.57	1.62	1.75	1.39	1.84	1.65
Soluble silica (mg/L)	1.44	1.05	1.18	1.07	1.33	0.86
Calcium (mg/L)	29.0	26.6	26.6	27.0	27.0	25.0
Magnesium (mg/L)	7.2	6.9	7.2	7.1	6.9	7.0
Chlorophyll a (µg/L)	<0.5	1.8	1.4	<0.5	1.3	1.7

in higher mean soluble phosphorous concentrations at the former locations (Figure 7). Filtrable orthophosphorous measurements primarily estimate the amount of orthophosphate available for algal assimilation. The maximum concentration of filtrable orthophosphorous was present on June 17 at Bruce GS 'A' forebay (16 µg/L), while low concentrations were found at other locations (8-10 µg/L) (Tables III and IV).

Concentrations of total Kjeldahl nitrogen were maximal in spring at all locations, with peak values ranging from 0.73 mg/L in Bruce GS 'A' forebay and discharge to approximately 0.90 mg/L in Sand Bay and Gunn Point (Tables III and IV). Seasonal lows were recorded on November 10, and ranged between 0.13 mg/L at Bruce GS 'A' forebay and discharge and 0.16 mg/L at Gunn Point. The pattern of distribution of soluble nitrogen (Figure 7) was similar to that for total Kjeldahl nitrogen. Particulate nitrogen concentrations which could be measured were minute with the maximum value recorded at Sand Bay on June 17 (0.32 mg/L). Nitrite (NO_2) could not be detected in the surface waters near BNPD, a phenomenon typical of oligotrophic waters (Wetzel, 1975). Nitrate (NO_3) had a similar seasonal distribution at all sampling locations. May highs near 2.0 mg/L nitrate declined to early fall (September 30) values of 1.1 mg/L nitrate, a range characteristic of BNPD sampling sites (Ontario Hydro Research Division Report Nos 82-107-K and 82-182-K).

Total silica concentrations did not differ substantially among locations, with seasonal mean values within 0.20 mg/L of one another (Tables III and IV). Variable soluble silica levels were found at the four sampling sites (Figure 7). Whereas a seasonal high of 1.37 mg/L occurred at Sand Bay on June 17, values near 1 mg/L were obtained for Bruce GS 'A' forebay and discharge, and the soluble silica concentration at Gunn Point was only 0.64 mg/L (Figure 7). The large variation in spring soluble silica values may reflect differences in succession rates of the diatomaceous algal populations of the separate sampling locations (Wetzel, 1975). The soluble silica content of Sand Bay samples decreased sharply in July to 0.79 mg/L and then rose to over 1.00 mg/L during the remaining months. However, except for the sample taken in August, soluble silica levels steadily declined throughout the summer and fall at Bruce GS 'A' discharge (Figure 7). In both the Bruce GS 'A' forebay and Gunn Point locations, a second minor peak in soluble silica concentration occurred on September 30, when levels reached 1.30 mg/L and 1.07 mg/L, respectively.

Seasonal chlorophyll a concentrations reflected a bimodal distribution pattern at all sampling locations (Figure 8). On May 13 and August 27, the chlorophyll a content of all water samples was below the limit of detection (0.5 µg/L). Mean

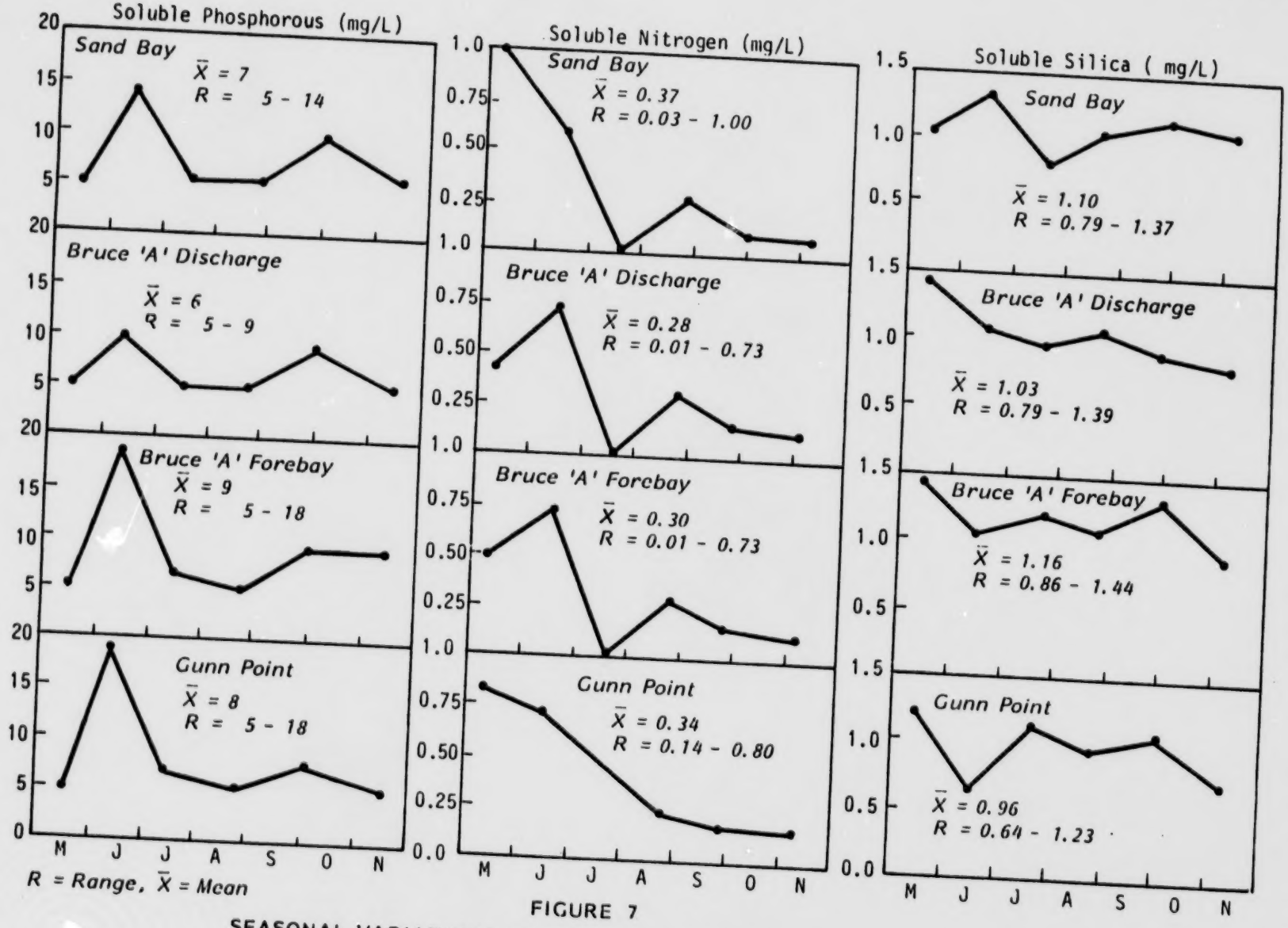

FIGURE 7

SEASONAL VARIATIONS IN NUTRIENT PARAMETERS MONITORED DURING ONPP YEAR III AQUATIC SURVEY 1981

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chlorophyll a concentrations were very similar and ranged from 1.1 µg/L at Bruce GS 'A' forebay to 1.2 µg/L at Sand Bay, Gunn Point and Bruce GS 'A' discharge (Figure 8). These values are characteristic of Lake Huron (Kwiatkowski, 1980).

Seasonal distribution patterns for both suspended and dissolved solids were similar in Bruce GS 'A' discharge and forebay (Figure 9). In both locations the mean suspended solid concentrations at 105°C and 550°C were approximately the same (1.6 mg/L and 1.1-1.2 mg/L in the discharge and forebay, respectively). Sand Bay and Gunn Point samples had slightly greater mean suspended solid concentrations at 105°C (mean values 2.5 and 2.3 mg/L, for Sand Bay and Gunn Point, respectively), a consequence of higher spring and fall concentrations. At all sampling sites except Gunn Point, the quantity of suspended organic material was marginally reduced in July and August.

Resuspension of fine particles in the water column during spring and fall turnover probably increased the mean concentration of suspended solids at Sand Bay. The Gunn Point value most likely reflects the input of fine material derived from adjacent bay areas (eg, Holmes Bay) or the Bruce GS 'B' construction site.

The mean concentration of dissolved solids at 105°C and at 550°C ranged from 118 and 90 mg/L at Bruce GS 'A' forebay to 122 and 99 mg/L at Bruce GS 'A' discharge, respectively (Figure 9). Variation in the levels of dissolved solids occurred at all locations sampled, however the temporal pattern was essentially similar and involved spring (June) and fall (September and November) declines in the concentration of dissolved solids (Figure 9). At Bruce GS 'A' forebay the change in concentration of dissolved solids measured at 550°C was particularly sharp, dropping from 103 mg/L in May, to 65 mg/L in June. Levels of dissolved solids consistent with those at other locations were restored in Bruce GS 'A' forebay during July (Figure 9).

Turbidity levels also showed a consistent seasonal pattern at all sampling locations, ranging between 1.0 and 1.5 NTU in spring and early summer, decreasing to <0.5 NTU in August, and increasing to ≥ 1.5 NTU in fall (Figure 9). The turbidity level at Sand Bay escalated to 2.5 NTU during the fall, exceeding the level at other locations by at least 0.5 NTU (Figure 9). This result was probably due to the resuspension of fine particles at Sand Bay during fall turnover.

Inshore surface lake pH ranged from 7.8 to 8.3 and was similar for the four sampling locations (Tables III and IV). Specific conductance was measured in surface lake water samples taken

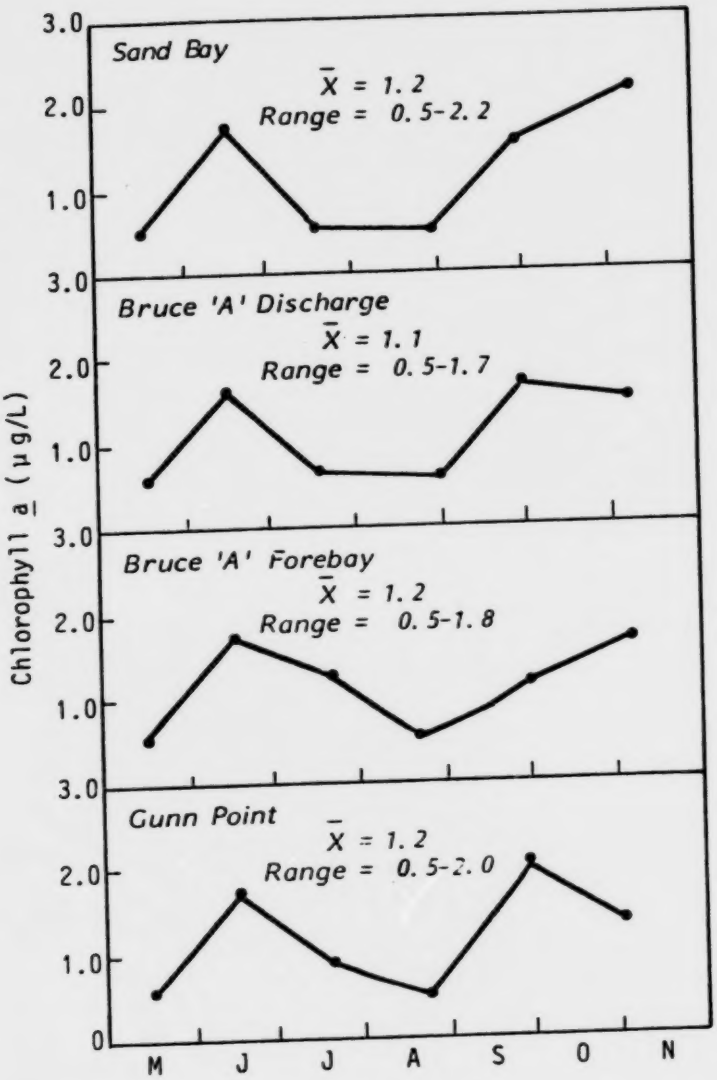

FIGURE 8

SEASONAL CONCENTRATIONS OF CHLOROPHYLL a (µg/L) OBTAINED DURING BNPD YEAR III AQUATIC SURVEY - 1981

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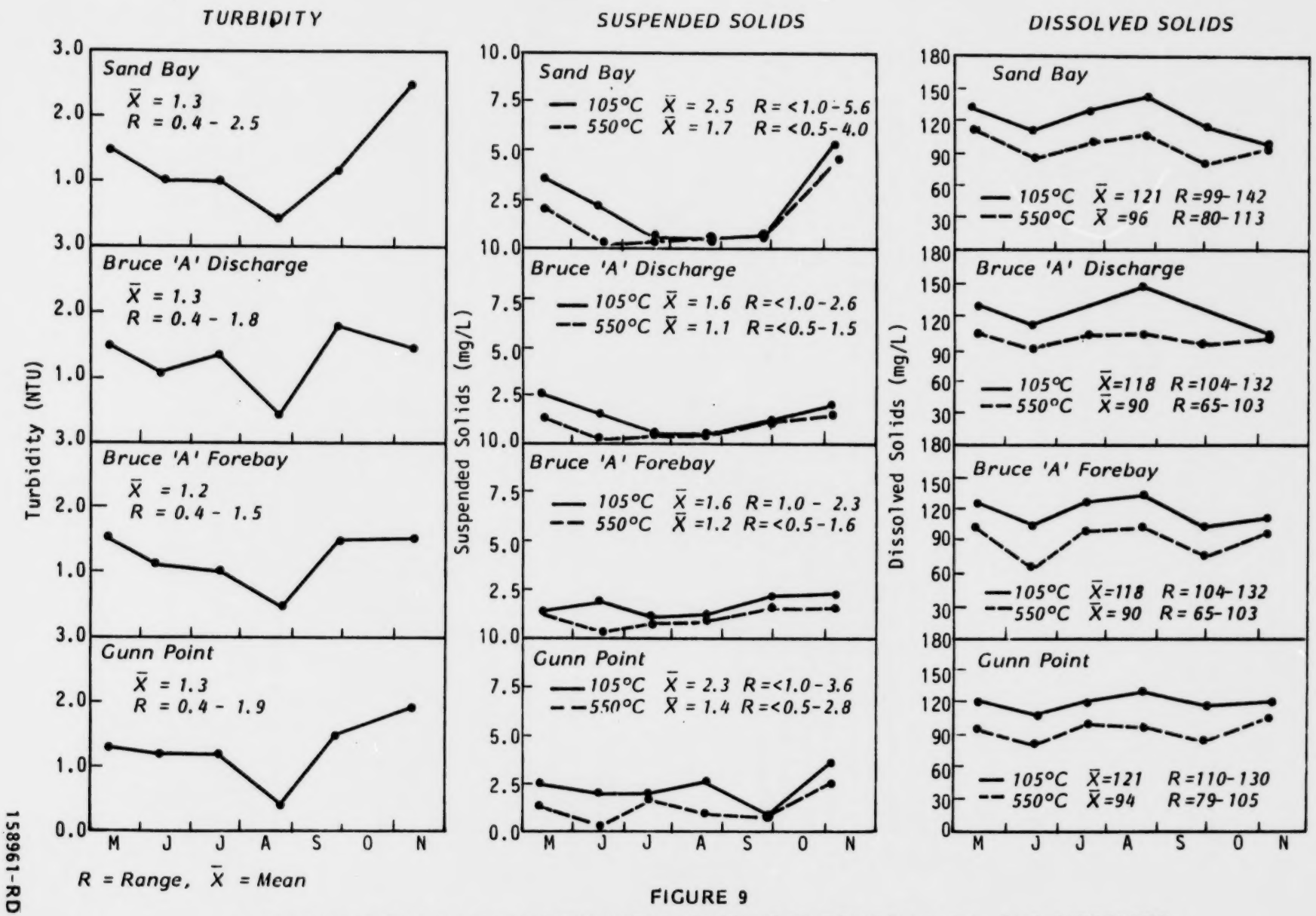
TURBIDITY
SUSPENDED SOLIDS
DISSOLVED SOLIDS
Turbidity (NTU)
Suspended Solids (mg/L)
Dissolved Solids (mg/L)
Sand Bay
X̄ = 1.3
R = 0.4 - 2.5
Bruce 'A' Discharge
X̄ = 1.3
R = 0.4 - 1.8
Bruce 'A' Forebay
X̄ = 1.2
R = 0.4 - 1.5
Gunn Point
X̄ = 1.3
R = 0.4 - 1.9
105°C X̄ = 2.5 R = <1.0-5.6
550°C X̄ = 1.7 R = <0.5-4.0
105°C X̄ = 1.6 R = <1.0-2.6
550°C X̄ = 1.1 R = <0.5-1.5
105°C X̄ = 1.6 R = 1.0 - 2.3
550°C X̄ = 1.2 R = <0.5-1.6
105°C X̄ = 2.3 R = <1.0-3.6
550°C X̄ = 1.4 R = <0.5-2.8
105°C X̄ = 121 R = 99-142
550°C X̄ = 96 R = 80-113
105°C X̄ = 118 R = 104-132
550°C X̄ = 90 R = 65-103
105°C X̄ = 118 R = 104-132
550°C X̄ = 90 R = 65-103
105°C X̄ = 121 R = 110-130
550°C X̄ = 94 R = 79-105
M J J A S O N
R = Range, X̄ = Mean

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FIGURE 9

SEASONAL LEVELS OF TURBIDITY (NTU), SUSPENDED SOLIDS (mg/L), AND DISSOLVED SOLIDS (mg/L) DURING BNPD YEAR III AQUATIC SURVEY - 1981

near the BNPD complex, and values between 17.0 and 20.0 mS/m were obtained over the sampling period (Tables III and IV).

Calcium concentrations were highest in May at all sampling sites, ranging from 28 mg/L at Gunn Point to 30 mg/L at Sand Bay. Lowest calcium concentrations occurred in November, when a value of 25 mg/L was obtained at all sites. Magnesium levels were relatively constant over the sampling period and at all sampling sites, with values fluctuating between 6.8 and 7.5 mg/L (Tables III and IV).

In general few differences existed between levels of water quality parameters measured at Bruce GS 'A' discharge and at other locations sampled. The main source of variation in the data presented is temporal. For most parameters the temporal trend was typified by high spring concentrations, followed by low summer values and moderately high fall concentrations. Some parameters, including nitrates and silicates, occurred in highest concentrations during the summer, while several parameters eg, calcium, magnesium and pH occurred within fairly narrow concentration ranges. Observed spatial differences did not appear to result from the thermal plume which was apparent at Bruce GS 'A' discharge during 1981.

3.3 Biological Characteristics

3.3.1 Attached Algae

Nineteen taxa of attached algae and three taxa of epiphytic algae were collected in the shoreline samples from the BNPD sites in 1981. Nine of the attached algal species and two of the epiphytes were found in 1979 (Ontario Hydro Research Division Report No 82-107-K). Additional species collected in 1981 include Bulbochaete and Calothrix, both of which were common and dominant on at least one occasion. Lyngbya was common at some locations in 1979, but absent in 1981. Due to the taxonomic similarities between species such as Lyngbya and Oscillatoria (Prescott, 1962), it is likely that some of the differences in species composition between 1979 and 1981 represent difficulties in the identification of sparse material rather than true shifts in species composition.

Shoreline Composition

The composition of the attached algal samples from the BNPD shoreline sampling sites is shown in Table V. The data are very heterogeneous with no two locations exhibiting identical seasonal patterns of change in species composition. Ulothrix spp dominated in May at all locations south of Transect L except Baie du Doré and Douglas Point. The spring dominance of

TABLE V

[illegible] PER CENT COMPOSITION OF ATTACHED ALGAE AT [illegible] LOCATIONS 1969-1970

Samples Containing Detritus Only Were Omitted During Averaging.
0 = no algae; + = present

May

Species	Location	Sand Bay	Transect K	Transect L	Scott Point	Bate du Dore	Bruce 'A' Discharge	Macpherson Bay	BNPP Discharge	Douglas Point	Gunn Point
ATTACHED ALGAE											
Amphora sp											
Bellerochea sp											
Calothrix sp											
Chaetoceros gimgeratia			96	3							
Cladophora sp											
Colonthonia sp											
Dictyocha sp											
Diatomella sp		99		44	13	70		3	2	62	4
Diatomina sp											
Dictyocha sp											
Fleurosigma sp											
Gomphonema sp											
Grammatophora sp											
Hyalosiphonia sp		4							1		
Licmophora sp		34		14	53	87	30	3 97	97	38	98
Navicula sp											
Nitzschia sp											
Rhizosolenia curvata		+	+	+	+	+	+	+	+	+	+

June

Species	Location	Sand Bay	Transect K	Transect L	Scott Point	Bate du Dore	Bruce 'A' Discharge	Macpherson Bay	BNPP Discharge	Douglas Point	Gunn Point
ATTACHED ALGAE											
Amphora sp											
Bellerochea sp											
Calothrix sp											
Chaetoceros gimgeratia											
Cladophora sp											
Colonthonia sp											
Dictyocha sp											
Diatomella sp		100				100					
Diatomina sp											
Dictyocha sp											
Fleurosigma sp											
Gomphonema sp											
Grammatophora sp				100			65				
Hyalosiphonia sp											
Licmophora sp											
Navicula sp											
Nitzschia sp											
Rhizosolenia curvata		+	+	+	+	+	+	+	+	+	+

July

Species	Location	Sand Bay	Transect K	Transect L	Scott Point	Bate du Dore	Bruce 'A' Discharge	Macpherson Bay	BNPP Discharge	Douglas Point	Gunn Point
ATTACHED ALGAE											
Amphora sp				0							
Bellerochea sp		70			27	92			97		98
Calothrix sp		30			36	5	17			1	63
Chaetoceros gimgeratia					37					17	
Cladophora sp											
Colonthonia sp										1	
Dictyocha sp											
Diatomella sp					1	2 12	83	7	1	58	9
Diatomina sp											
Dictyocha sp										21	
Fleurosigma sp											
Gomphonema sp											
Grammatophora sp								12			
Hyalosiphonia sp											
Licmophora sp											
Navicula sp			100					1		1	2
Nitzschia sp								14			7
Rhizosolenia curvata		+		+	+	+	+	+	+	+	+

August

Species	Location	Sand Bay	Transect K	Transect L	Scott Point	Bate du Dore	Bruce 'A' Discharge	Macpherson Bay	BNPP Discharge	Douglas Point	Gunn Point
ATTACHED ALGAE											
Amphora sp											0
Bellerochea sp		12	7	15	47	43		27			
Calothrix sp		88	93	85	53	13		7	3		
Chaetoceros gimgeratia						37					
Cladophora sp											
Colonthonia sp											
Dictyocha sp											
Diatomella sp						8		14	1	1	
Diatomina sp										11	
Dictyocha sp											
Fleurosigma sp								28	97		
Gomphonema sp							100				
Grammatophora sp											
Hyalosiphonia sp										86	
Licmophora sp								1			
Navicula sp											
Nitzschia sp								22			
Rhizosolenia curvata		+				+ + +		+	+		

September

Species	Location	Sand Bay	Transect K	Transect L	Scott Point	Bate du Dore	Bruce 'A' Discharge	Macpherson Bay	BNPP Discharge	Douglas Point	Gunn Point
ATTACHED ALGAE											
Amphora sp											
Bellerochea sp		10	12		3		13				
Calothrix sp		90	88	100	77	27	30	7			33
Chaetoceros gimgeratia											67
Cladophora sp											
Colonthonia sp											
Dictyocha sp											
Diatomella sp					12	11	7	15	11	20	
Diatomina sp						44			10	10	
Dictyocha sp											
Fleurosigma sp								8	66		
Gomphonema sp					8			5			
Grammatophora sp									2		
Hyalosiphonia sp							41				
Licmophora sp									1	63	
Navicula sp								65		7	
Nitzschia sp											3
Rhizosolenia curvata					+	+	+	+	+	+	+

October

Species	Location	Sand Bay	Transect K	Transect L	Scott Point	Bate du Dore	Bruce 'A' Discharge	Macpherson Bay	BNPP Discharge	Douglas Point	Gunn Point
ATTACHED ALGAE											
Amphora sp											
Bellerochea sp			23	17	10			12	4		
Calothrix sp		80	67	80	27	60			6		63
Chaetoceros gimgeratia										19	
Cladophora sp											
Colonthonia sp							21				
Dictyocha sp							37	46	4	1	14
Diatomella sp			7		3	25	3		3		
Diatomina sp									2		
Dictyocha sp											
Fleurosigma sp								16	72		
Gomphonema sp		20			67	13					
Grammatophora sp											
Hyalosiphonia sp							40		8	3	
Licmophora sp				3				17		8	35
Navicula sp								10	7	66	
Nitzschia sp					3	12					12
Rhizosolenia curvata					+	+	+	+	+	+	+

Ulothrix is consistent with observations of the distribution of this species in the Great Lakes (Taft, 1975; Rosemarin, 1980; Ontario Hydro Research Division Report No 82-107-K). Calothrix was dominant or codominant at all locations north of the Bruce GS 'A' discharge except Baie du Doré from August to October, but had not been previously observed as a dominant species at BNPD.

Despite the marked spatial heterogeneity in species composition, an overall shift in dominance from Ulothrix and Mougeotia in May and June to Calothrix and Rhizoclonium in August to October is apparent from Table V. Seasonal patterns were also exhibited by Bulbochaete and Cladophora, both of which were absent before July.

As a consequence of the spatial heterogeneity, it is difficult to compare the discharge areas with the lakeshore locations, except to note that the species found at the discharge locations were not unique to those locations.

Three species of epiphytes were found on the shoreline attached algae, of which Cymbella was the most common. This species did not exhibit any trend seasonally or spatially. Rhoicosphenia curvata similarly did not exhibit a spatial trend, but occurred infrequently after May. Cocconeis was rare. These trends are similar to those observed at the Bruce 'B' sampling sites in 1981 (Ontario Hydro Research Division Report in preparation).

Transect Samples

The composition of the samples collected at the 1, 3, 7 and 12 m depths at Gunn Point and the 3 m depth at Sand Bay and Baie du Doré are shown in Tables VI and VII. Data from the locations within the Bruce GS 'A' discharge are not available due to improper preservation of the samples.

No attached algae occurred at the 1 m to 12 m depths sampled at Gunn Point in June, but Bulbochaete and Calothrix were prominent offshore at 3 m to 12 m depths in August. October sampling revealed that Rhizoclonium dominated at 7 m depth, Bulbochaete and Zygnema codominated at 3 m depth, and a mixture of algae occurred at 1 m depth (Table VI).

Calothrix dominated at the shoreline and 3 m depth in Sand Bay during August and October. Syctonema and Calothrix were dominant at the 3 m depth of Baie du Doré in August and October, respectively (Table VII). At times when algae were found at these locations, the composition was similar regardless of the depth from which they were taken. The overall seasonal patterns are similar to those described above for the shoreline samples. The lack of data for Bruce GS 'A' discharge precludes a fuller assessment of spatial variability in algal composition at BNPD.

TABLE VI

MEAN PER CENT COMPOSITION OF ATTACHED ALGAE AT THE SHORE AND THE 1 m, 3 m, 7 m and 12 m DEPTH CONTOURS AT GUNN POINT BNPD-1981

(Samples containing detritus only were not averaged.)

0 = no algae; + = algae present

Depth Contour	June					August					October				
	S	1 m	3 m	7 m	12 m	S	1 m	3 m	7 m	12 m	S	1 m	3 m	7 m	12 m
ATTACHED ALGAE		0	0	0	0	0	0								0
Bulbochaete sp								57	43			33	50		
Calothrix sp								40	47	50	43	33			
Mougeotia sp											10				
Oedogonium sp									3	25					
Rhizoclonium sp									2	25		33		100	
Scytonema sp									5						
Ulothrix sp											35				
Ulothrix zonata	100														
Zygnema sp											12		50		
EPIPHYTES															
Cymbella	+							+	+	+	+	+			

TABLE VII

MEAN PER CENT COMPOSITION OF ATTACHED ALGAE AT THE SHORE AND 3 m DEPTH CONTOUR AT SAND BAY AND BAIE DU DORE BNPD-1981

(Samples containing detritus only were not averaged)

0 = no algae; + = algae present

Depth Contour	June				August				October			
	Sand Bay		Baie du Doré		Sand Bay		Baie du Doré		Sand Bay		Baie du Doré	
	S	3 m	S	3 m	S	3 m	S	3 m	S	3 m	S	3 m
ATTACHED ALGAE		0	0	0								
Bulbochaete					12		43	30			10	
Calothrix					88	100	13		80	70	40	100
Cladophora glomerata							37					
Mougeotia	100							15		5	25	
Oedogonium							8			25		
Rhizoclonium									20			
Schizothrix								55			13	
Scytonema											12	
Zygnema												
EPIPHYTES												
Cocconeis						+	+	+			+	
Cymbella							+					
Rhoicosphenia curvata												

Biomass

The ash-free dry weights of the samples collected at the shoreline locations are given in Appendix 3. Many of the samples from June, September and October consisted entirely or mainly of detritus and the weights obtained overestimate attached algal biomass. These samples are indicated by an * in Appendix 3. The weights of attached algal samples not containing detritus ranged from 0 g/m^2 (Gunn Point in August) to 108.5 g/m^2 (BHWP discharge in October). The maximum monthly mean weight occurred at the Bruce GS 'A' discharge in October (70.3 g/m^2).

In order to examine the data for differences between stations and months, a two-way ANOVA was computed following transformation to a natural logarithmic scale. The transformation was required to meet the assumption of homogeneity of variance (Snedecor and Cochran, 1967). Data from June, September and October were omitted from the analysis while samples from other months with little or no algae were assigned a zero weight prior to the ANOVA. The two way interaction term (station x month) was significant at the 95% level ($F=8.52$, 18, 60) indicating that the seasonal trend of algal growth was not uniform across locations. This is not an unexpected result given the diverse patterns in monthly mean biomass evident in Figure 10. A similar lack of consistent trends in biomass was observed in 1979 (Ontario Hydro Research Division Report No 82-107-K).

Statistical comparisons were not made between the samples collected at different depths at Gunn Point, Baie du Doré and Sand Bay since most of these samples consisted mainly of detritus (Appendix 4). This suggests that the algae, although present were very sparse.

3.3.2 Benthic Macroinvertebrates

A. Rock Cage Colonization

Taxonomic Composition

Benthic macroinvertebrates which colonized rock cages consisted of 21, 988 organisms representing 12 taxa (Table VIII). The benthic collection was dominated numerically by oligochaetes which comprised over 30% of the total. The Diptera, Amphipoda, Ephemeroptera, Trichoptera and Gastropoda accounted for 20%, 19%, 10%, 9% and 9% of the overall benthic collection, respectively. The remaining taxa each contributed <1% to the total (Table VIII).

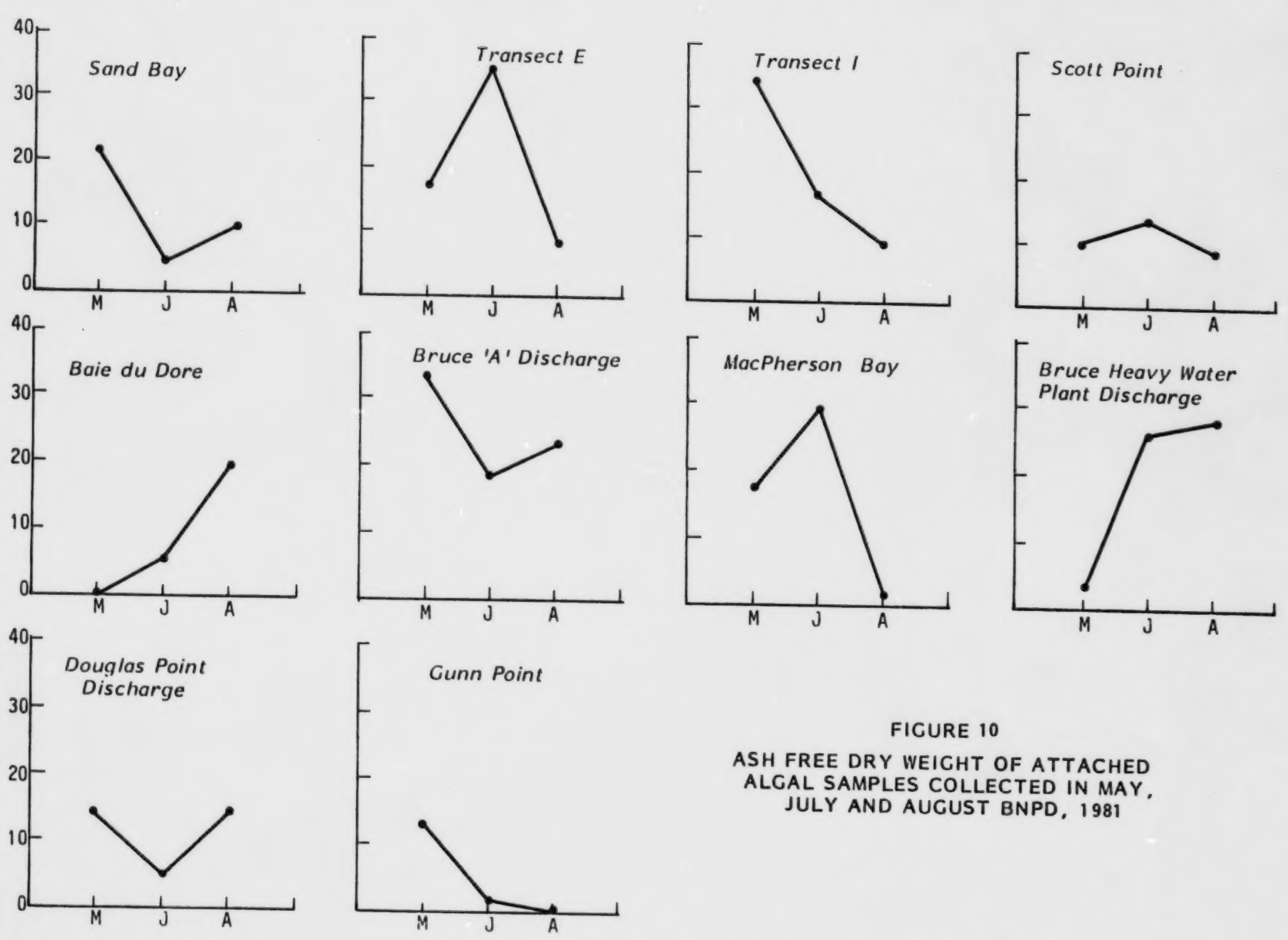

FIGURE 10

ASH FREE DRY WEIGHT OF ATTACHED ALGAL SAMPLES COLLECTED IN MAY, JULY AND AUGUST BNPD, 1981

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TABLE VIII

SUMMARY OF ABUNDANCE AND PERCENT COMPOSITION OF MAJOR BENTHIC MACROINVERTEBRATE TAXA (CLASSES AND ORDERS) COLLECTED IN ROCK CAGES AT BNPD - 1981

Class (C) or Order (O)		No of Organisms	%
Oligochaeta	(C)	6 777	30.83
Diptera	(O)	4 505	20.49
Amphipoda	(O)	4 160	18.92
Ephemeroptera	(O)	2 163	9.84
Trichoptera	(O)	2 070	9.42
Gastropoda	(C)	1 929	8.78
Isopoda	(O)	131	0.59
Decapoda	(O)	124	0.56
Acarina	(C)	111	0.50
Hirudinea	(C)	12	0.05
Pelecypoda	(C)	5	0.02
Zygoptera	(O)	1	0.00
Total		21 988	100.00

Abundance and Distribution of Benthic Macroinvertebrates

A detailed listing of the benthic macroinvertebrates collected is provided in Appendix 5 (on microfilm). Although oligochaetes dominated the collection numerically, they were not uniformly distributed over the sampling area. Nais pardalis was collected almost exclusively at the 3 m depth contour of Bruce GS 'A' discharge on July 2 (Tables IX and X). The large number of Nais pardalis collected greatly exceeded the rock cage collections ot this species made during the 1975 and 1979 aquatic surveys (Ontario Hydro Research Division Report Nos 76-343-K and 82-107-K).

Nais variabilis was the dominant oligochaete at BHWP discharge during June, July and August and was also prominent at Macpherson Bay and Douglas Point in August (Table IX). The different concentrations of naid species at the discharge locations may reflect microhabitat variability, although the present data are insufficient to confirm this idea.

The dipteran Cladopelma spp was only found at the 3 m depth contour of Bruce GS 'A' discharge on July 2 (Tables IX and X). The concentration of this species at a single location (864 individuals) is peculiar since this species was absent from 1975, 1977, 1978 and 1979 rock cage collections (Ontario Hydro Research Division Report Nos 76-343-K, 78-395-K, 80-43-K and 82-107-K). It is not clear whether the restricted occurrence of Cladopelma spp is a function of higher water temperatures at Bruce GS 'A' discharge or rock cage sampling variability. The trichopteran Cheumatopsyche spp had maximum abundance in Baie du Doré during August, and October/November sampling periods. Cheumatopsyche spp was noticeably more prevalent in the northern portion of the study area (Sand Bay to Baie du Doré) and virtually absent from the more southerly locations, including the discharge locations (Table IX).

Both Gammarus fasciatus (amphipod) and Physa gyrina (gastropod) were encountered in large numbers in Baie du Doré during the July and October/November sampling periods. During August, G. fasciatus and P. gyrina had maximum abundance at Bruce GS 'A' discharge and Baie du Doré, respectively (Table IX).

Averaged over the entire sampling period, the greatest benthic macroinvertebrate concentrations occurred at Baie du Doré and Bruce GS 'A' discharge. However the average concentration of benthic macroinvertebrates at Baie du Doré greatly exceeded that at Bruce GS 'A' discharge (711) (Table IX).

TABLE IX

LONGSHORE DISTRIBUTION OF BENTHIC MACROINVERTEBRATES COLLECTED IN DUPLICATE ROCK CAGES
BNPD - 1981

Retrieval Date	Taxa	Sand Bay	Scott Point	Baie du Doré	Bruce 'A' Discharge	Bruce 'A' Intake	Macpherson Bay	BNWP Discharge	Douglas Pt Discharge	Gunn Point
June 2-18	Nais pardalis	0	0	2	3	0	0	5	0	0
	Cheumatopsyche spp	3	2	5	0	0	0	0	0	0
	Nais variabilis	0	0	18	6	0	3	117	10	0
	Gammarus fasciatus	0	8	31	14	7	2	5	9	0
	Gammarus spp	0	1	100	14	3	1	2	5	0
	Physa gyrina	0	0	0	0	0	2	4	0	0
	Hyalella azteca	11	17	10	5	13	6	6	8	0
	Cladopelma spp	0	0	0	0	0	0	0	0	0
	Cricotopus [isocladius]	0	3	42	6	0	0	0	0	0
	ALL TAXA	122	146	403	105	73	82	277	82	0
July 2	Nais pardalis	0	0	19	3552	0	2	20	0	0
	Cheumatopsyche spp	1	0	4	1	0	0	0	0	0
	Nais variabilis	0	1	254	87	30	33	294	35	16
	Gammarus fasciatus	0	2	286	75	6	19	12	7	2
	Gammarus spp	12	15	119	162	79	26	30	36	23
	Physa gyrina	22	47	209	0	10	0	2	13	0
	Hyalella azteca	30	30	27	17	91	20	20	36	7
	Cladopelma spp	0	0	0	864	0	0	0	0	0
	Cricotopus [isocladius]	24	18	170	21	19	71	63	62	51
	ALL TAXA	499	682	1505	5404	491	468	812	462	415
Aug 13-20	Nais pardalis	0	0	0	0	0	1	3	0	0
	Cheumatopsyche spp	182	152	642	5	0	5	0	1	9
	Nais variabilis	2	1	0	36	25	181	430	125	2
	Gammarus fasciatus	3	8	43	424	0	33	51	27	64
	Gammarus spp	10	77	23	171	131	111	52	55	21
	Physa gyrina	8	17	232	67	36	4	100	55	28
	Hyalella azteca	97	39	62	18	52	81	35	79	25
	Cladopelma spp	0	0	0	0	0	0	0	0	0
	Cricotopus [isocladius]	21	32	22	32	19	99	34	34	10
	ALL TAXA	710	980	1307	1177	564	806	926	581	429
Oct 5- 6 & Nov 3-12	Nais pardalis	0	0	0	0	0	0	0	0	0
	Cheumatopsyche spp	5	18	682	0	0	5	0	0	0
	Nais variabilis	0	0	0	0	0	0	0	0	0
	Gammarus fasciatus	0	0	223	14	0	35	0	1	15
	Gammarus spp	0	0	23	0	0	0	0	0	0
	Physa gyrina	0	2	172	3	1	4	0	1	8
	Hyalella azteca	47	41	6	0	3	64	0	16	11
	Cladopelma spp	0	0	0	0	0	0	0	0	0
	Cricotopus (isocladius)	0	0	0	0	0	0	0	0	0
	ALL TAXA	124	156	1545	59	11	251	0	44	87
Sampling Period Average	Nais pardalis	0	0	5.2	888.7	0	0.7	7.0	0	0
	Cheumatopsyche spp	47.7	43	333.2	1.5	0	2.5	0	0.2	2.2
	Nais variabilis	0.5	0.5	68.0	32.2	13.7	54.2	210.2	42.5	4.5
	Gammarus fasciatus	0.7	4.5	145.7	131.7	3.2	22.2	17.0	11.0	20.2
	Gammarus spp	5.5	23.2	66.2	86.7	53.2	34.5	21.0	24.0	11.0
	Physa gyrina	7.5	16.5	110.2	17.5	11.7	2.5	26.5	17.2	9.0
	Hyalella azteca	46.2	31.7	26.2	10.0	39.2	42.7	15.2	34.7	10.7
	Cladopelma spp	0	0	0	216.0	0	0	0	0	0
	Cricotopus (isocladius)	11.2	13.2	58.5	14.7	9.5	42.5	24.2	24.0	15.2
	ALL TAXA	363.7	491.0	1240.0	711.2	284.7	401.7	503.7	292.2	263.7

TABLE X

DISTRIBUTION BY DEPTH FOR BENTHIC MACROINVERTEBRATES COLLECTED IN DUPLICATE ROCK CAGES, BNPD - 1981

Retrieval Date	Taxa	Contour Depth (m)		
		3 m	7 m	12 m
June 2-18	Nais pardalis	10	0	0
	Cheumatopsyche spp	10	0	0
	Nais variabilis	143	9	2
	Gammarus fasciatus	62	9	5
	Gammarus spp	115	10	1
	Physa gyrina	1	2	3
	Hyalella azteca	46	28	2
	Cladopelma spp	0	0	0
	Cricotopus (isocladius)	49	1	1
	ALL TAXA	954	204	131
July 2	Nais pardalis	3591	1	1
	Cheumatopsyche spp	6	0	0
	Nais variabilis	659	62	29
	Gammarus fasciatus	387	11	11
	Gammarus spp	268	188	46
	Physa gyrina	283	4	16
	Hyalella azteca	128	117	33
	Cladopelma spp	864	0	0
	Cricotopus (isocladius)	291	153	55
	ALL TAXA	8655	1310	773
Aug 13-20	Nais pardalis	3	0	12
	Cheumatopsyche spp	975	18	3
	Nais variabilis	618	127	57
	Gammarus fasciatus	525	54	74
	Gammarus spp	125	256	270
	Physa gyrina	461	31	63
	Hyalella azteca	271	129	88
	Cladopelma spp	0	0	0
	Cricotopus (isocladius)	190	62	51
	ALL TAXA	4662	1497	1524
Oct 5- 6 & Nov 3-12	Nais pardalis	0	0	0
	Cheumatopsyche spp	710	0	0
	Nais variabilis	0	0	0
	Gammarus fasciatus	258	20	10
	Gammarus spp	23	0	0
	Physa gyrina	185	5	1
	Hyalella azteca	162	25	1
	Cladopelma spp	0	0	0
	Cricotopus (isocladius)	0	0	0
	ALL TAXA	2103	148	26
Sampling Period Average	Nais pardalis	901.0	0.2	3.25
	Cheumatopsyche spp	440.2	4.5	0.7
	Nais variabilis	355.0	49.5	22.0
	Gammarus fasciatus	308.0	23.5	25.0
	Gammarus spp	231.7	67.5	79.2
	Physa gyrina	232.5	10.5	20.7
	Hyalella azteca	151.7	74.7	31.0
	Cladopelma spp	216.0	0	0
	Cricotopus (isocladius)	132.5	54.0	26.7
	ALL TAXA	4093.5	789.8	613.5

If the large concentrations of N. pardalis and Cladopelma spp are excluded, only the August collection of benthic macroinvertebrates at Bruce GS 'A' discharge was large, when compared to Baie du Doré collections. The Gunn Point location was consistently associated with the least number of benthic organisms, except for the October/November sampling period, when no benthic fauna were found at the BHWP discharge.

There was a heavy concentration of benthic organisms in rock cages close inshore along the 3 m depth contour during all sampling periods (Table X). Overall abundance of benthic macroinvertebrates generally declined substantially with distance from shore. For example in July benthic organisms proliferated in the inshore zone (8655 organisms collected) and were much less abundant at the 7 m and 12 m depth contours (1310 and 773 organisms, respectively, Table X). However, during the August sampling period numbers of benthic organisms collected at the 12 m depth contour slightly exceeded those collected at the 7 m depth contour. It should be re-emphasized that the above benthic macroinvertebrate distribtion patterns are not completely representative of natural concentrations, but rather reflect rock cage colonization during the sampling period in question.

Benthic Macroinvertebrate Diversity

The Shannon-Wiener index was used to measure the extent of evenness in taxonomic composition. Low values indicate low diversity and high values indicate high diversity.

Diversity indices ranged from 1.45 at the 3 m depth contour of Bruce GS 'A' discharge in July (where Cladopelma spp and N. pardalis dominated numerically) to 4.30 at the 7 m depth contour of Sand Bay in August (Table XI). The lowest mean monthly diversity index occurred during the October/November sampling period (2.73), and was exceeded by, in increasing order of mean diversity indices, June (2.99), August (3.38) and July (3.50) (Table XI).

Over the year the mean diversity ranged from 2.84 at Bruce GS 'A' discharge to 3.47 at Gunn Point. There was no consistent spatial or temporal trend in the diversity indices except that values at Baie du Doré declined as the season progressed.

Distribution of Zoobenthic Assemblages

Mutual Information Analysis (Orloci, 1969) was used to describe the benthic community in terms of assemblages which have similar diversity indices and taxonomic composition. Table XII shows

TABLE XI

SPATIAL AND TEMPORAL DISTRIBUTIONS OF SHANNON-WIENER DIVERSITY INDICES AT BNPD (ROCK CAGES), 1981

Retrieval Date	Contour Depth (m)	Sand Bay	Scott Point	Baie du Doré			Bruce 'A' Discharge	Bruce 'A' Intake	Macpherson Bay	BNPP Discharge	Douglas Pt Discharge	Gunn Point	Depth Contour Mean
				C	D	E							
June 2-18	3	3.46	3.86	4.26	3.50	3.31	3.19	3.04	2.81	1.89	3.66	-	3.29
	7	2.35	3.43				2.43	2.55	2.15	3.29	3.62	-	2.83
	12	2.05	2.39				2.46	1.91	3.03	3.52	-	-	2.56
	Trans mean	2.62	3.22		3.69		2.69	2.50	2.66	2.90	3.64		2.99
July 2	3	3.65	3.57	3.57	2.82	3.11	1.45	3.77	4.12	3.04	3.76	4.26	3.37
	7	4.08	4.10				3.46	3.50	3.48	3.96	3.79	4.09	3.80
	12	3.03	2.02				3.07	3.79	4.00	3.65	4.02	3.54	3.39
	Trans mean	3.58	3.23		3.16		2.66	3.68	3.86	3.55	3.85	3.96	3.50
Aug 13-20	3	3.27	2.99	2.39	3.28	3.64	2.47	3.14	3.22	2.07	3.27	4.13	3.07
	7	4.30	4.23				3.61	3.19	3.56	3.71	3.48	4.15	3.47
	12	3.56	3.09				3.39	3.71	3.41	3.50	3.27	3.46	3.42
	Trans mean	3.71	3.43		3.10		3.15	3.34	3.39	3.09	3.34	3.91	3.38
Oct 5-6 & Nov 3-12	3	2.25	3.06	1.82	2.19	2.83	-	2.41	3.64	-	-	2.53	2.59
	7	-	-				2.89	-	-	-	2.77	3.36	3.00
	12	-	-				-	-	-	-	-	1.76	1.76
	Trans mean	2.25	3.06		2.28		2.89	2.41	3.64		2.77	2.55	2.73
Year	Trans mean	3.04	3.23		3.04		2.84	2.98	3.38	3.18	3.40	3.47	3 m 3.08 7 m 3.27 12 m 2.78

- no data available (see text)

the seven zoobenthic assemblages ascribed to the fauna which colonized rock cages. Stenonema tripunctatum and Hyalella azteca were prominent in Assemblage 1. Assemblage 2 was comprised of a large number of taxa with low representation (<10%), but Nais variabilis and N. simplex together represented 15% of this assemblage. Assemblages 3, 4, 6 and 7 were respectively dominated by the taxa Gammarus spp, Nais variabilis, Gammarus fasciatus and Nais pardalis. Assemblages 3 and 6 were probably very similar since Gammarus spp may represent G. fasciatus juveniles. Cheumatopsyche spp and Physa gyrina were the most prominent benthic organisms in Assemblage 5.

The spatial and temporal distribution of zoobenthic assemblages is presented in Table XIII. Assemblages 1 and 2 were the most widely distributed assemblages, with Assemblage 1 occurring more frequently in June, Assemblage 2 gaining prominence in July.

The most noticeable feature of Table XIII is the single occurrence of Assemblage 7 (composed of 70% Nais pardalis) at the 3 m depth contour of Bruce GS 'A' discharge in July, consistent with the very high numbers of this organism collected (Tables IX and X).

Assemblage 5 was prevalent in shallow water (3 m depth contour) at the northern end of the study area (Sand Bay to Baie du Doré). Assemblage 6 occurred at the 3 m depth contour of Bruce GS 'A' discharge in August, and in Baie du Doré during October/November. Assemblage 3 occurred along the 7 m depth contour at Bruce GS 'A' discharge and intake during July and August and at the 12 m depth contour of Scott Point, Bruce GS 'A' intake and MacPherson Bay in August. Nais variabilis dominated Assemblage 4, which was present in shallow water (except for 7 m depth contour at BHWP discharge) in MacPherson Bay and BHWP discharge.

Baie du Doré and the inshore areas of Sand Bay and Scott Point were colonized by assemblages which were relatively unique (5,6) and by taxa (eg. Gammarus fasciatus) reflecting on unexposed conditions and the presence of aquatic macrophytes. Locations south of Bruce GS 'A' intake had greater proportions of cobble and gravel substrate, and had assemblages which were characterized by rock-inhabiting organisms (eg, Naididae) (Table XIII). Bruce GS 'A' discharge and intake areas were colonized by assemblages which were not consistent from one sampling period to the next. Assemblages dominated by naids (2,7) occurred mainly at inshore areas (3 m depth contour) of Bruce GS 'A' discharge and intake during July, while assemblages dominated by amphipods or dipterans (3,5,6) prevailed at 7 m depth contour locations in July and at both 3 m and 7 m depth contour locations in August. Since the latter assemblages were

TABLE XII

PERCENT COMPOSITION OF ZOOBENTHIC ASSEMBLAGES
(ROCK CAGE DATA), BNPD - 1981

Species		Assemblages						
		1	2	3	4	5	6	7
Nais pardalis	(O)	0	0	0	1	0	0	70
Nais variabilis	(O)	1	8	5	40	0	0	1
Gammarus fasciatus	(A)	6	6	0	8	2	40	1
Gammarus spp	(A)	4	9	31	5	2	3	2
Cheumatopsyche spp	(T)	1	1	0	0	22	0	0
Stenonema tripunctatum	(E)	17	4	4	0	0	0	0
Hyalella azteca	(A)	11	7	7	4	5	0	0
Physa gyrina	(G)	4	1	1	3	13	20	0
Cladopelma spp	(D)	0	0	0	0	0	0	17
Gammarus pseudolimnaeus	(A)	8	2	8	1	0	0	0
Cricotopus (isocladius)	(D)	1	9	4	7	4	1	0
Stenonema interpunctatum	(E)	5	2	1	0	1	0	0
Nais simplex	(O)	2	7	2	7	2	0	0
Heptagenia spp	(E)	3	5	3	2	4	0	0
Psectrocladius nr simulans	(D)	3	7	9	3	2	0	0

O = Oligochaeta
A = Amphipoda
T = Trichoptera
E = Ephemeroptera
G = Gastropoda
D = Diptera

TABLE XIII

SPATIAL AND TEMPORAL DISTRIBUTION OF ZOOBENTHIC ASSEMBLAGES (ROCK CAGE DATA), BNPD - 1981

Month	Contour Depth (m)	Sand Bay	Scott Point	Baie du Doré			Bruce 'A Discharge	Bruce 'A' Intake	Macpherson Bay	BHWP Discharge	Douglas Pt Discharge	Gunn Point
		A	B	C	D	E	F	G	H	I	J	K
June	3	2	2	2	2	2	2	1	2	4	1	-
	7	1	1				1	1	1	1	2	-
	12	1	1				1	1	1	1	-	-
July	3	5	5	5	4	4	7	2	2	4	2	2
	7	1	1				3	3	2	2	2	1
	12	1	1				1	2	2	2	1	2
Aug	3	5	5	5	5	5	6	5	4	4	4	2
	7	2	1				3	3	2	4	2	1
	12	1	3				1	3	3	2	1	1
Oct/Nov	3	1	1	5	6	6	-	1	1	-	-	1
	7	-	-				1	-	-	-	1	1
	12	-	-				-	-	-	-	-	1

A - K = Transect codes

\- = no data available (see text)

observed more frequently north of Bruce GS 'A' discharge whereas naid-dominated assemblages were more prominent south of Bruce GS 'A' intake, the intermediate area (Bruce GS 'A' discharge and intake) may represent a transition zone for assemblage type and thus predominant taxonomic groups. Warmer inshore temperatures at Bruce GS 'A' discharge and changing substrate type along a north-south axis are likely two important factors influencing this transition.

B. Vacuum Dome Samples

Taxonomic Composition

Oligochaeta, Diptera and Acarina accounted for about 88% of the benthic organisms collected in vacuum dome samples during August 20-31 (Table XIV). As in the rock cage samples, oligochaetes were prominent in the vacuum done collections. Nais pardalis and Pseudosmittia spp were the most abundant benthic organisms collected, with mean densities of 201 organisms/m^2 each (Table XIV). In contrast to rock cage collections, N. pardalis was more widely distributed over the entire sampling area (Table XV). Other abundant oligochaetes were N. simplex (133$m/^2$), N. variabilis (55/m^2) and N. elinguis (38/m^2). The ephemeropteran Caenis spp had a moderate mean density of 69 organisms/m^2 (Table XIV).

Spatial Distribution and Density

Nais pardalis was prominent along the Bruce GS 'A' discharge transect where a mean density of 1034/m^2 was noted, and in Baie du Doré where the highest mean density was 775/m^2. Very few N. pardalis individuals were collected north of Baie du Doré, and numbers at Gunn Point were low.

Nais simplex occurred in moderate densities at some locations, ie Transect L (between Sand Bay and Scott Point) and Bruce GS 'A' intake (279/m^2 and 302/m^2, respectively), while at other locations mean densities were rather low, ie Baie du Doré (0-15/m^2) and Gunn Point (39/m^2). However, the distribution of this oligochaete was not as restricted as that of N. pardalis (Table XV). Learner et al (1978) suggested that temperature and current velocity were two important factors influencing the distribution of naids. Ancillary observations at benthic collection sites indicated that differences in substrate type and algal cover were minimal at the 3 m depth contour of four of the northernmost sampling locations (Sand Bay, Scott Point, Baie du Doré and Bruce GS 'A' discharge), where a boulder substrate covered with short green algae predominated (Ontario Hydro Research Division Report Nos 82-107-K and 82-182-K). The widespread distribution of N. simplex suggests that substrate type may influence oligochaete distribution even when

TABLE XIV

PERCENT COMPOSITION AND MEAN DENSITIES (NUMBERS/m^2) OF DOMINANT MACROINVERTEBRATE TAXA COLLECTED IN THE VICINITY OF BNPD IN VACUUM DOMES, 1981

Macroinvertebrate Taxa		Mean Density (Numbers/m^2)	%
Nais pardalis	(O)	201	15.88
Caenis spp	(E)	69	5.49
Pseudosmittia spp	(D)	201	15.88
Nais simplex	(O)	133	10.47
Nais variabilis	(O)	55	4.31
Orthocladiinae	(D)	51	4.05
Acarina		76	6.00
Pseudochironomus spp	(D)	56	4.39
Nais elinguis	(O)	38	3.04
Dicrotendipes spp	(D)	57	4.48

O = Oligochaeta E = Ephemeroptera D = Diptera

gradients of temperature exist along the shoreline. The presence of elevated temperatures at discharge locations may create nearshore environmental conditions which favour the abundance of naids such as N. pardalis.

The greatest mean density of the dipteran Pseudosmittia spp was observed at Transect L (457/m^2), where the abundance of this organism declined with increasing depth. Pseudosmittia spp was distributed quite randomly over the sampling area, in contrast to the most abundant ephemeropteran Caenis spp, which was primarily found at Baie du Doré. Acarina was represented at most locations sampled, but was also at maximum density in Baie du Doré , although the mean density of this group was relatively high at the 7 m depth contour of Bruce GS 'A' discharge (Table XV).

Given the distributions of the dominant benthic organisms as outlined above, it is not surprising that the highest overall mean density (all taxa combined) occurred at Baie du Doré (2976 organisms/m^2). Bruce GS 'A' discharge also recorded a high overall mean density (2181 organisms/m^2), while Sand Bay was associated with the lowest overall mean density of benthic organisms (713/m^2).

Although no clear pattern of depth distribution of benthic macroinvertebrates was noted, overall the greatest mean density occurred along the 7 m depth contour (1731 organisms/m^2). Caenis spp was much more abundant in the shallow water area (1 m depth contour) of Baie du Doré than farther offshore (Table XV). N. pardalis was heavily concentrated at the 3 m depth contour of Baie du Doré and Bruce GS 'A' discharge.

Diversity Indices and Community Structure

Diversity of benthic organisms was extremely low at one site in Baie du Doré (0.25), where only two taxa, Acarina and Pseudosmittia spp, were found (Table XVI). The mean diversity index for that station was consequently quite low (1.12). The highest mean diversity index along a transect occurred at Scott Point (2.88), and the 7 m depth contour was associated with the greatest mean density index of all depth contours sampled (2.98). Mean diversity indices were slightly greater at the northern sampling locations (Sand Bay to Scott Point) than at southern locations such as Gunn Point (Table XVI). Diversity indices of benthic organisms collected by vacuum domes were lower than those of benthic organisms collected by rock cages during August (Tables XI and XVI). The most likely explanation for this difference is the larger number of taxa which occurred in rock cages, which have a more complex substrate structure (Appendix 5).

TABLE XV

SPATIAL VARIATION IN DENSITIES (NUMBERS/m^2) OF BENTHIC INVERTEBRATES COLLECTED IN VACUUM DOME SAMPLES AT BNPD, 1981

Taxa	Depth Contour (m)	Sand Bay	Transect L	Scott Point	Baie Du Doré			Bruce 'A' Discharge	Bruce 'A' Intake	Gunn Point	Depth Contour Mean
					C	D	E				
All Taxa	1	248	2914	930	3286	713	651	-	0	0	1093
	3	434	1860	806	2666	744	1054	3132	2077	713	1498
	7	1271	1798	1581	-	-	-	2666	1364	1705	1731
	12	899	155	1116				744	465	713	712
	Trans Mean	713	1682	1108	2976	729	856	2181	977	783	
Nais pardalis	1	0	31	0	62	0	0	-	0	0	12
	3	0	0	0	1488	0	527	2047	496	0	506
	7	0	0	0	-	-	-	992	31	0	171
	12	0	0	0	-	-	-	62	0	93	31
	Trans Mean	0	8	0	775	0	264	1034	132	23	
Pseudosmittia spp	1	31	930	62	31	0	0	-	0	0	131
	3	62	465	0	186	31	93	341	186	434	200
	7	403	434	372	-	-	-	186	248	186	305
	12	124	0	496	-	-	-	62	186	279	191
	Trans Mean	155	457	233	109	15	47	196	155	224	
Nais simplex	1	0	496	31	31	0	0	-	0	0	70
	3	93	186	186	0	0	31	0	620	0	124
	7	186	434	186	-	-	-	0	527	155	248
	12	217	0	310	-	-	-	248	62	0	140
	Trans Mean	124	279	178	15	0	15	83	302	39	
Acarina	1	0	0	31	279	155	217	-	0	0	85
	3	31	0	31	62	713	0	62	62	31	110
	7	31	31	31	-	-	-	248	0	62	67
	12	0	0	0	-	-	-	93	31	0	21
	Trans Mean	15	8	23	171	434	109	134	23	23	
Caenis spp	1	0	0	93	1426	341	31	-	0	0	236
	3	0	31	62	0	0	0	0	0	0	23
	7	0	0	31	-	-	-	0	0	0	5
	12	0	0	0	-	-	-	0	0	0	0
	Trans Mean	0	8	47	713	171	15	0	0	0	

TABLE XVI

SPATIAL DISTRIBUTION OF SHANNON-WIENER DIVERSITY INDICES
AT BNPD 1981 - VACUUM DOME

Transect	Contour Depth (m)				Transect Mean
	1	3	7	12	
Sand Bay	1.75	3.18	2.91	2.83	2.66
Transect L	3.25	3.24	2.88	1.52	2.72
Scott Point	-	3.30	3.22	2.14	2.88
Baie du Doré C	2.90	2.38			2.64
D	2.01	0.25			1.12
E	2.30	2.70			2.50
Bruce 'A' Discharge	0	1.91	3.03	3.13	2.01
Bruce 'A' Intake	0	2.32	2.73	2.60	1.91
Gunn Point	-	1.35	3.11	2.69	2.38
Depth Contour Mean	1.74	2.29	2.98	2.48	2.37

Mutual Information Analysis revealed four primary zoobenthic assemblages (Table XVII). Groups 1, 3 and 4 were characterized by the dominant taxa Pseudosmittia spp, Nais pardalis and N. simplex respectively. Assemblage 2 exhibited shared dominance between N. pardalis and Acarina, with Caenis spp also fairly prominent.

The distribution of these zoobenthic assemblages is shown in Table XVIII. Assemblage 1, dominated mainly by Pseudosmittia spp, occurred at all locations sampled except Baie du Doré, in which only Assemblage 2 occurred. Sand Bay, Gunn Point and Transect L locations were highly characterized by Assemblage 1. Assemblage 3, which was composed of a large proportion of N. pardalis, occurred only at the 7 m depth contour of Bruce GS 'A' discharge, while Assemblage 4, dominated by N. simplex, was found at the 3 m and 7 m depth contours of Bruce GS 'A' intake. Thus assemblages which contained relatively small proportions of oligochaetes and large proportions of dipterans (eg, Assemblage 1) occurred more frequently at the northern end of the sampling area (Sand Bay to Scott Point) and at Gunn Point. Assemblages containing large proportions of oligochaetes were concentrated near the Bruce GS 'A' discharge and intake locations. At Baie du Doré, situated between the northern locations and the Bruce GS 'A' discharge and intake locations, Assemblage 2 exhibited more equal proportions of oligochaetes and dipterans, and an additional taxon, Acarina, occupied a more prominent position within the zoobenthic community.

Areas of Baie du Doré where vacuum dome samples were collected had large proportions of cobble and gravel which probably provided suitable substrate for clinger-type benthic organisms such as naids and Acarina (Assemblage 2). More northerly locations (Sand Bay, Transect L and Scott Point and Gunn Point) had higher proportions of sand or bedrock, as reflected in the prevalence of dipterans (Assemblage 1) (Tables XVII and XVIII).
Bruce GS 'A' discharge and intake areas had mixed assemblages as noted for rock cage collections.

3.3.3 Ichthyoplankton

Taxonomic Composition

A total of 5896 fish larvae were collected in lake tows and forebay sets at BNPD during the period April through August, 1981. Fish larvae consisted of 21 taxa contained in 12 distinct families (Table XIX). Alewife larvae comprised 45% of the total catch, followed by smelt (26%), carp (18%) and cyprinid (5%)larvae. Johnny darter larvae represented 2% of the catch,

TABLE XVII

PERCENT COMPOSITION OF ZOOBENTHIC ASSEMBLAGES
(VACUUM DOME DATA) BNPD, 1981

Species	Assemblage			
	1	2	3	4
Nais pardalis	1	19	37	13
Pseudosmittia spp	22	4	7	14
Nais simplex	11	3	0	34
Acarina	2	19	9	2
Nais variabilis	2	0	13	22
Nais elinguis	6	1	3	0
Caenis spp	0	13	0	0
Pseudochironomus spp	3	9	2	1
Dicrotendipes spp	4	5	7	2
Orthocladiinae	5	0	1	0

TABLE XVIII

SPATIAL AND TEMPORAL DISTRIBUTION OF ZOOBENTHIC ASSEMBLAGES (VACUUM DOME DATA), BNPD - 1981

Depth Contour (m)	Sand Bay A	Transect L	Scott Point B	Baie Du Doré			Bruce 'A' Discharge F	Bruce 'A' Intake G	Gunn Point K
				C	D	E			
1	1	1	-	2	2	2	1	1	-
3	1	1	2	2	2	2	2	4	1
7	1	1	1				3	4	1
12	1	1	1				1	1	1

A - L = Transect Codes
- = no data available (see text)

Macpherson Bay, BHWP discharge and Douglas Point discharge locations were not sampled due to rough weather conditions.

while all other taxa combined accounted for the remaining 4% of the total catch (Table XIX). Only a few fish eggs were collected (135), of which 127 (94%) were alewife. Seven smelt eggs and one (1) carp egg were also found (Table XIX).

Alewife larvae were fairly abundant in the BNPD nearshore environment. Fewer alewife larvae were captured during the 1979 aquatic survey (Ontario Hydro Research Division Report No 82-107-K). Larvae of carp, gizzard shad, trout-perch, mottled sculpin and slimy sculpin were absent from the 1979 larval fish tows, but present in the 1981 tows.

Abundance and Distribution

Smelt

Smelt larvae were most abundant in nearshore waters during May (Figure 11). On May 14 and 20, 652 and 678 larval smelt, were caught, accounting for 93 and 98% of the total larval fish catch, respectively. Numbers of smelt larvae declined in surface waters by May 28, when only 30 larvae were collected. Although 124 larvae were captured on June 10, less than 10 larvae were collected on all subsequent sampling dates (Figure 11, Appendix 6).

Throughout the period of peak abundance (May 14-28) smelt larvae were approximately 6.0 mm in mean total length (Figure 12, Appendix 7). Since these larvae were slightly larger than newly-hatched fish (about 5 mm according to Scott and Crossman, 1973), the approximate hatching time was in early May. If a three week spawn-to-hatch incubation period is assumed (Scott and Crossman, 1973), spawning probably occurred during the latter part of April. Mean total length of smelt larvae increased to only 7.4 mm by June 24, however after that date mean total length of smelt larvae increased rapidly, reaching 21.0 mm by July 7 and 37.4 mm by August 20, the final sampling date (Figure 12, Appendix 7).

Smelt larvae were captured in offshore locations (3 m and 7 m depth contours) on May 14 (Figure 13). Highest densities of larval smelt on that date were recorded at the 3 m depth contour of Scott Point (Transect B), Bruce GS 'A' discharge (Transect F) and Douglas Point discharge (Transect J), with the maximum density recorded at Scott Point (2070/1000 m^3) (Figure 13, Appendix 8). Smelt larvae had appeared close inshore at the 1 m depth contour by May 20, and with the exception of the 3 m depth contour in Baie du Doré, were absent from offshore locations. The maximum larval smelt density (4780/1000 m^3) occurred at the BHWP discharge transect (I) followed by Douglas Point discharge (Transect J) (1940/1000 m^3). In contrast to the distribution

TABLE XIX

TAXONOMIC COMPOSITION OF LARVAL FISH AND EGGS COLLECTED IN SURFACE TOWS AT BNPD,1981

Taxon	Larvae		Eggs	
	Number	Per cent	Number	Per cent
Alewife	2679	45.4	127	94.1
Smelt	1512	25.6	7	5.2
Carp	1072	18.2	1	0.7
Cyprinidae	289	4.9		
Johnny Darter	104	1.8		
Burbot	82	1.4		
Gizzard Shad	67	1.1		
Yellow Perch	23	0.4		
Trout-Perch	16	0.3		
Deepwater Sculpin	11	0.2		
Cisco	11	0.2		
Mottled Sculpin	7	0.1		
Slimy Sculpin	6	0.1		
White Sucker	5	0.1		
Percidae	4	0.1		
Pumpkinseed	2	<0.1		
Logperch	2	<0.1		
Cottidae	1	<0.1		
Gasterosteidae	1	<0.1		
Brown Bullhead	1	<0.1		
Golden Shiner	1	<0.1		
TOTAL	5896		135	
(Number of Taxa)	(21)		(3)	

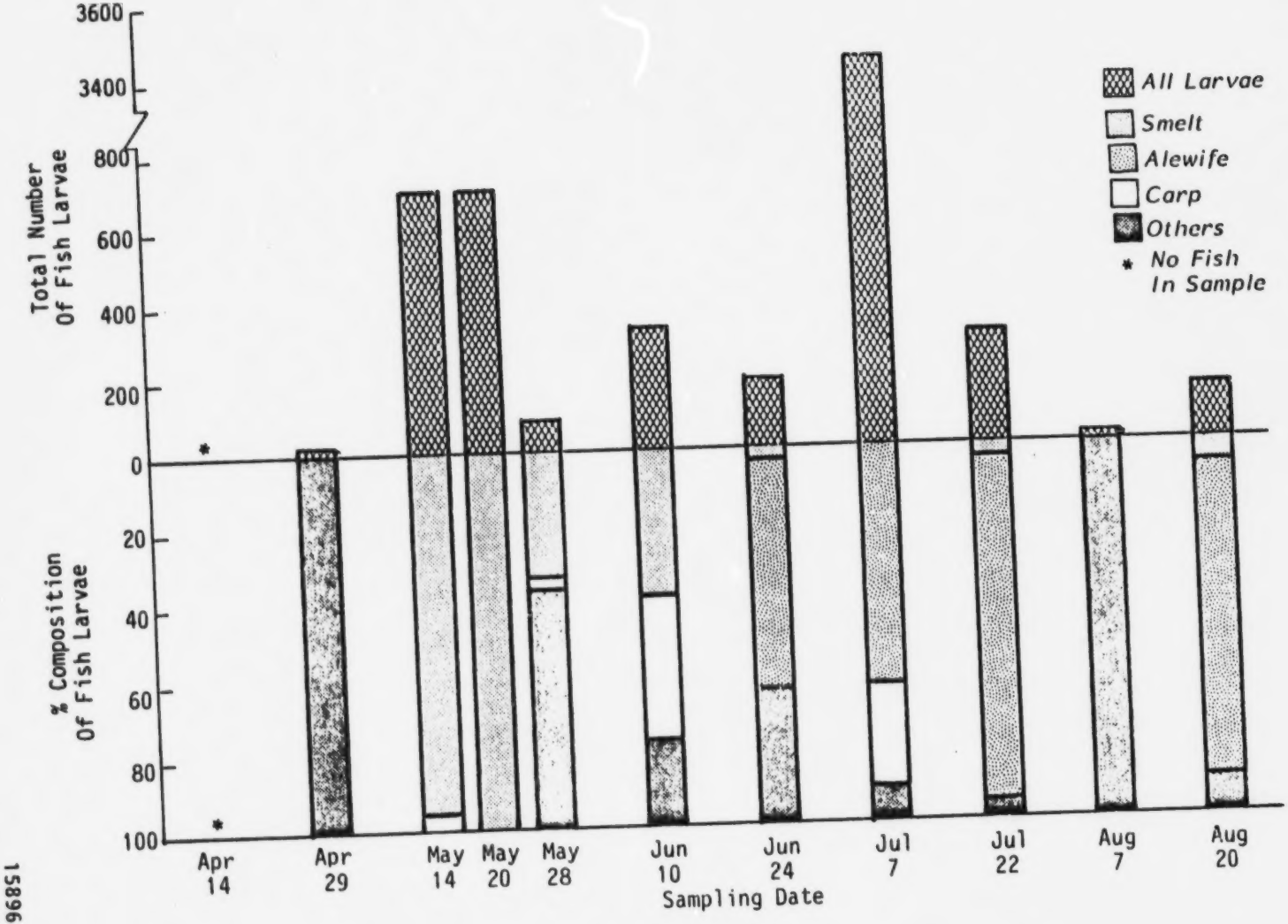

FIGURE 11

TEMPORAL ABUNDANCE AND COMPOSITION OF LARVAL FISH COLLECTED AT BNPD, 1981

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pattern observed on earlier sampling dates, larval smelt (mean total length 6.8 mm) were distributed fairly evenly over all locations on June 10, although marginally higher densities (120-130/1000 m^3) were obtained at the 1 m and 3 m depth contours of the Bruce GS 'A' discharge (Figure 13, Appendix 8). Notably, densities of smelt larvae in Bruce GS 'A' forebay were highest on June 10 (410/1000 m^3), and may be indicative of movement of young smelt into deeper waters, since larval smelt surface densities were very low on subsequent sampling dates.

Alewife

Only 111 alewife larvae were collected on June 24, the date these larvae were first taken in the BNPD nearshore zone (Figure 11, Appendix 6). On that date (June 24) alewife larvae had a mean total length of 5.0 mm (Figure 12, Appendix 7)) and were more concentrated inshore (1 m depth contour) than offshore (3 m depth contour), particularly in Baie du Doré (Figure 13, Appendix 8). The majority of alewife larvae (2166) were captured in surface tows on July 7 (Figure 11). At that time larval alewife, still a mere 5.3 mm in mean total length (Figure 12), were markedly concentrated in the inshore waters (1 m depth contour) along the Bruce GS 'A' and BHWP discharge and Bruce GS 'A' intake transects, with densities in excess of 4000/1000 m^3 (Figure 13, Appendix 8). Moderate densities (150-360/1000 m^3) were recorded in Baie du Doré (1 m and 3 m isobaths), while the greatest larval alewife density at Scott Point was 550/1000 m^3 (at the 7 m depth contour location of Scott Point) (Figure 13, Appendix 8). Densities were fairly high along the 3 m depth contour where values ranging from 170/1000 m^3 at Scott Point to 3700/1000 m^3 at BHWP discharge were recorded (Figure 13, Appendix 8).

High concentrations of alewife larvae were still within the sampling area on July 22. Densities exceeding 600/1000 m^3 occurred at the 1 m and 3 m depth contours of Transect C and the 1 m depth contour of Transect D in Baie du Doré (Figure 13, Appendix 8). Larval alewife concentrations were low ($\leq$110/1000 m^3) at the remaining sampling locations.

Although no alewife larvae were caught in surface tows on August 7, some larvae were captured on August 20, and were generally observed in small concentrations over the sampling area (Figure 13). The maximum larval alewife density occurred at the 3 m depth contour of Transect D in Baie du Doré (250/1000 m^3) (Figure 13, Appendix 8).

Alewife larvae ranged between 5.0 mm and 5.3 mm in mean total length during the period corresponding to maximum surface

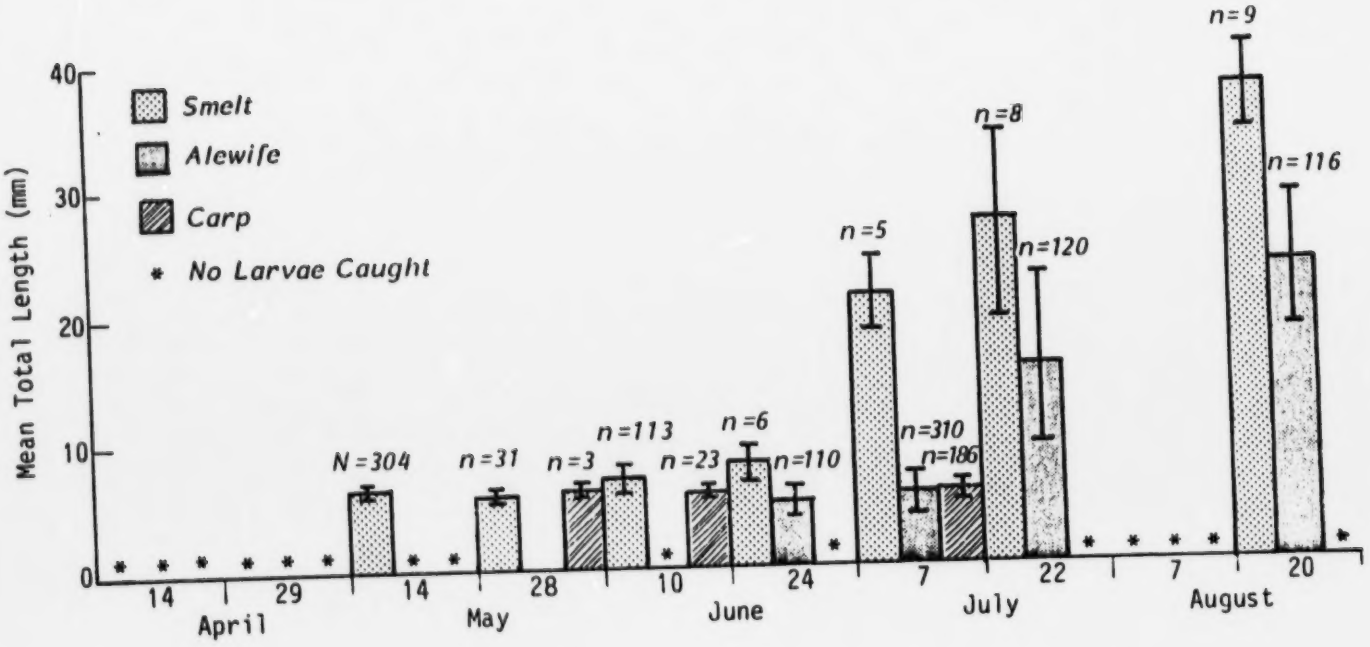

FIGURE 12

MEAN TOTAL LENGTH (± STANDARD DEVIATION) OF LARVAL SMELT, ALEWIFE AND CARP CAPTURED IN FOREBAY SETS AND LAKE TOWS - BNPD, 1981

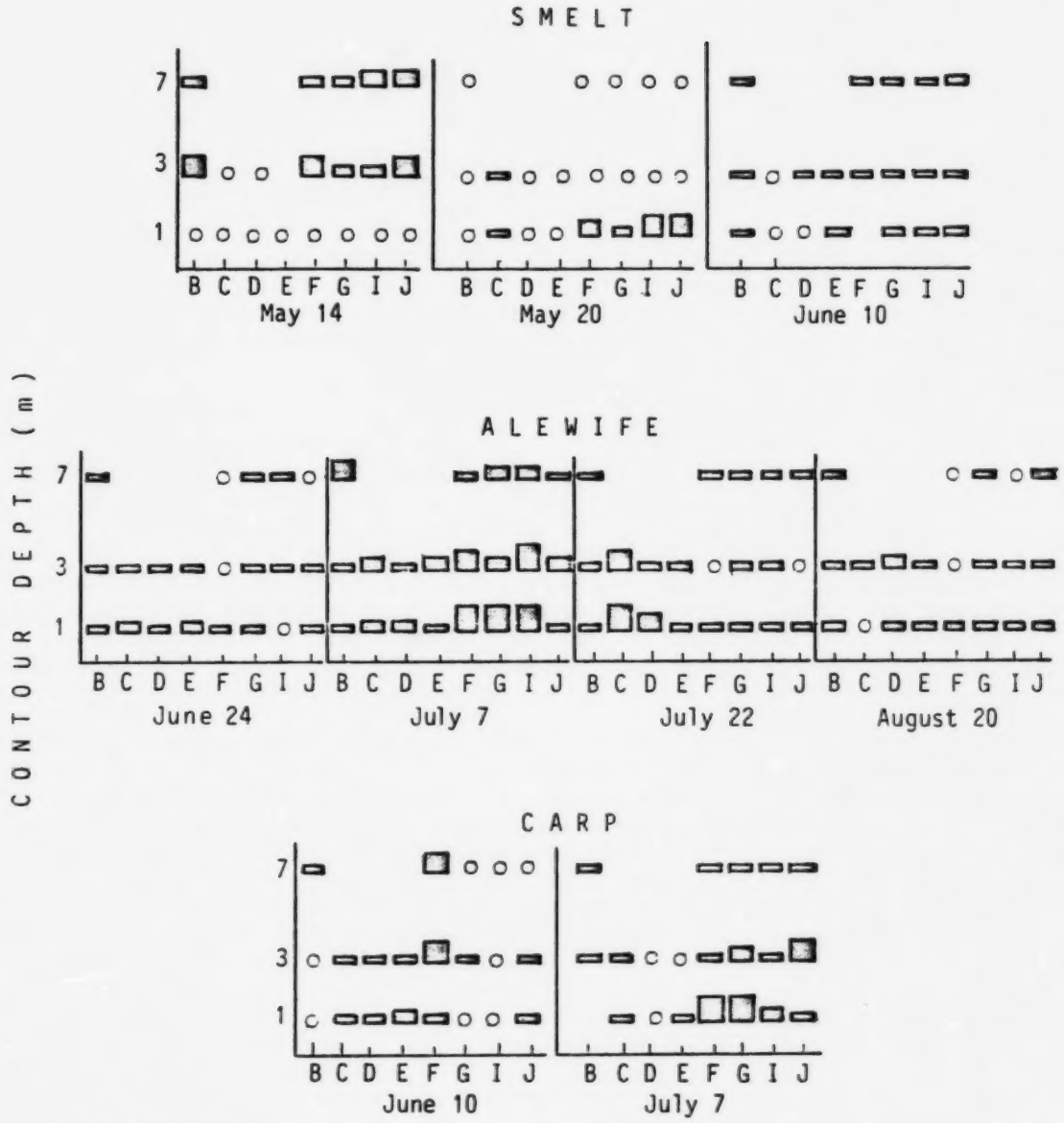

FIGURE 13

SPATIAL DISTRIBUTION OF LARVAL SMELT, ALEWIFE AND CARP DURING PERIODS OF PEAK DENSITY AT BNPD, 1981

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density (Figure 12, Appendix 7). The mean total length of alewife larvae was 16.0 mm on July 22 and 23.0 mm on August 20 (Figure 12, Appendix 7). These data, together with the larval alewife distribution data, suggest that as young alewife grow, they move out of the surface waters near the BNPD complex into the sheltered waters of Baie du Doré. It is possible that Baie du Doré serves as an early rearing area for young alewife until they migrate to deeper strata. Alternatively, spawning may occur sequentially along the shoreline, occurring first in the warmed Bruce GS 'A' discharge waters, and later in more northerly locations such as Baie du Doré.

Only a few larval alewife were caught in forebay sets, with densities of 10/1000 m^3 and 30/1000 m^3 recorded in Bruce GS 'A' forebay and Douglas Point forebay on July 7, respectively. No alewife larvae were caught in forebay sets on other sampling occasions.

Carp

The occurrence of carp larvae in surface waters within the sampling area was minimal on May 28 when three larvae were collected, and maximal on July 7 when 943 larvae were caught. On June 10, densities of carp larvae were highest at the 3 m and 7 m depth contour locations of the Bruce GS 'A' discharge transect (520 and 590/1000 m^3, respectively). Similarly the larval carp density at the 1 m depth contour of Transect E in Baie du Doré was the greatest among the locations sampled (270/1000 m^3) at that depth contour on June 10 (Figure 13, Appendix 8).

Few carp larvae were captured north of the Bruce GS 'A' discharge transect on July 7. High concentrations of larvae appeared inshore (1 m isobath) at Bruce GS 'A' intake and discharge locations (3100 and 6210/1000 m^3, respectively). Densities were rather low at most other sampling locations except for the 1 m isobath of the BHWP transect and the 3 m isobaths of the Bruce GS 'A' intake and Douglas Point discharge locations, where densities of carp larvae ranged between 240 and 540/1000 m^3 (Figure 13, Appendix 8).

Carp larvae had an almost constant mean total length (mean total length range = 6.1 mm - 6.3 mm) throughout the period when they were captured (Figure 12). These larvae were likely spawned within the sampling area, possibly in the southwestern portion of Baie du Doré (Transect E), or near Bruce GS 'A' (Transects F and G), based on distribution data (Figure 13).

The density of carp larvae in forebay sets was very low (10/1000 m^3 at BHWP forebay on June 10).

Other Fish Larvae

In general the abundance of other fish larvae in nearshore surface waters was quite low. The maximum number of other fish larvae occurred on July 7 when 325 larvae were collected (Figure 11, Appendix 6). Highest densities observed on July 7 ranged from 10/1000 m^3 for logperch and mottled sculpin, to 330/1000 m^3 for gizzard shad and johnny darter, and 480/1000 m^3 for cyprinids.

The majority of these relatively less abundant fish larvae, especially gizzard shad, cyprinid, percid and pumpkinseed larvae, were found mainly in Baie du Doré or near Scott Point (Appendix 9). A few larvae, such as cisco, sculpin and burbot larvae were largely associated with one or more of the discharge areas or with the Bruce GS 'A' intake area.

The greater abundance and number of larval fish species captured during the 1981 aquatic survey compared with the 1979 survey must be considered a direct result of the addition of 1 m depth contour sampling stations. Data obtained from the 1981 survey indicate that the young-of-the-year of many fish species are located close inshore along the Lake Huron shoreline in the vicinity of the BNPD complex during late spring and summer.

Larval Fish Entrainment

Estimates of larval entrainment based on densities obtained in forebay sampling are presented in Table XX. The mean number of smelt larvae entrained per day during May was estimated to be 1.2×10^6 at Bruce GS 'A', 2.5×10^4 at BHWP, and 3.2×10^4 at Douglas Point GS. Smelt larvae were also abundant in June when a mean of 2.7×10^6 larvae were estimated to be entrained per day at Bruce GS 'A' (Table XX). Larval alewife were not entrained in large quantities during July (approximately 7.1×10^4 per day at Bruce GS 'A') although the condenser cooling water flow was maximal (about 1.4×10^6 m^3 per day at Bruce GS 'A') in July (Table XX).

Larval smelt entrainment estimates for Bruce GS 'A' obtained in this study exceed estimates made in a 1977 larval fish entrainment study (Ontario Hydro Research Division Report No 78-192-K) by about one order of magnitude. This discrepancy may be the result of:

(i) two unit (1977) versus four unit (1981) operation, or

(ii) natural variation in larval smelt density.

TABLE XX

LARVAL ENTRAINMENT ESTIMATES, BNPD - 1981

Month	Station	Mean Daily Pumping Volume (m^3/day)	(Mean Density of Fish Larvae (No/m^3)) / Mean Number of Larvae Entrained Per Day					
			Smelt	Alewife	Deepwater Sculpin	Burbot	Other	
April	Bruce GS 'A'	10 800 000	-- --	-- --	(0.080) 864 000	-- --	-- --	
May	Bruce GS 'A'	12 096 000	(0.100) 1 209 600	-- --	(0.020) 241 920	(0.015) 181 440	(0.005) 60 480	(Cisco)
	BHWP	2 505 600	(0.010) 25 056	-- --	-- --	(0.020) 50 112	-- --	
	Douglas Pt GS	1 296 000	(0.025) 32 400	-- --	-- --	(0.020) 25 920	-- --	
June	Bruce GS 'A'	12 960 000	(0.205) 2 656 800	--	--	(0.075) 972 000	(0.005) 64 800	(Cisco)
	BHWP	2 073 600	(0.020) 41 472	-- --	-- --	-- --	(0.020) 41 472	(Carp)
	Douglas Pt GS	1 036 800	(0.005) 5 184	-- --	-- --	-- --	-- --	
July	Bruce GS 'A'	14 256 000	-- --	(0.005) 71 280	-- --	-- --	(0.005) 71 280	(Sculpin)
	BHWP	2 160 000	-- --	-- --	-- --	-- --	(0.005) 10 800	(Stickle back?)
	Douglas Pt GS	1 209 600	-- --	(0.015) 18 144	-- --	-- --	(0.005) 6 048	(Mottled Sculpin)
August	Douglas Pt GS	1 296 000	-- --	-- --	-- --	-- --	(0.005) 6 480	(Gizzard Shad)

3.3.4 Juvenile and Adult Fish

Taxonomic Composition and Abundance

A summary of the total fish catch and the separate catches for each gear method made at BNPD during 1981 is presented in Table XXI. A total of 11 874 fish representing 48 taxonomic groups (47 distinct species) was caught in beach seines, gill nets and trap nets (Table XXI). Appendix 9 (microfiche) contains the detailed fish catch data.

Spottail shiner was the most abundant fish species collected, contributing 26% (3086 fish) to the total catch. A catch of 2686 alewife represented 23% of the total fish catch. Other fish species, which were captured in smaller quantities, included in decreasing order of abundance, longnose sucker (1317 or 11%), bluntnose minnow (1198 or 10%), white sucker (1070 or 9%), gizzard shad (273 or 2%), brown bullhead (230 or 2%), and sand shiner (226 or 2%) (Table XXI). Commercially or recreationally important fish species collectively accounted for about 4% of the total catch, and included yellow perch (151), round whitefish (103), smallmouth bass (107), yellow pickerel (91), rainbow trout (8), chinook salmon (6), northern pike (5), coho salmon (4), white bass (2), pumpkinseed (2), pink salmon (1), and splake (1) (Table XXI). Single representatives of two relatively uncommon fish species, lake sturgeon and bowfin, were captured in a gill net and a trap net, respectively (Table XXI).

Beach Seines

The fish catch in beach seines over the entire sampling period was 5341 and was dominated numerically by spottail shiner (58%). Several other cyprinid species were collected, including bluntnose minnow (22%), sand shiner (4%), spotfin shiner (4%) and longnose dace (1%), with the total contribution by all cyprinids representing 95% of the overall beach seine catch. The remaining 5% of the beach seine catch consisted mainly of other small sized fish ie, clupeids, cottids and small percids (Table XXI).

Trap Nets

Six fish species accounted for approximately 96% of the overall trap net catch: alewife (29%), longnose sucker (25%), white sucker (23%), brown bullhead (9%), rock bass (7%), and smallmouth bass (4%). These species are frequently encountered in the littoral zone of lakes and are commonly caught in trap nets.

TABLE XXI

TOTAL FISH CATCH - ALL GEAR TYPES BNPD-1981

Taxon	Beach Seine		Trap Net		Gill Net		Total	
	No	Per Cent	No	Per Cent	No	Per Cent	No	Per Cent
Spottail Shiner	3 085	57.8	0	0.0	1	<0.1	3 086	26.0
Alewife	144	2.7	670	28.7	1 872	44.6	2 686	22.6
Longnose Sucker	0	0.0	582	24.9	735	17.5	1 317	11.1
Bluntnose Minnow	1 198	22.4	0	0.0	0	0.0	1 198	10.1
White Sucker	24	0.4	527	22.6	519	12.4	1 070	9.0
Gizzard Shad	54	1.0	2	0.1	217	5.2	273	2.3
Brown Bullhead	0	0.0	208	8.9	22	0.5	230	1.9
Sand Shiner	226	4.2	0	0.0	0	0.0	226	1.9
Cyprinidae	217	4.1	0	0.0	0	0.0	217	1.8
Spotfin Shiner	206	3.9	0	0.0	0	0.0	206	1.7
Rock Bass	0	0.0	164	7.0	32	0.8	196	1.6
Lake Chub	9	0.2	7	0.3	178	4.2	194	1.6
Yellow Perch	1	<0.1	32	1.4	118	2.8	151	1.3
Channel Catfish	0	0.0	6	0.3	118	2.8	124	1.0
Smallmouth Bass	3	<0.1	85	3.6	19	0.5	107	0.9
Round Whitefish	0	0.0	1	<0.1	102	2.4	103	0.9
Yellow Pickerel	0	0.0	0	0.0	91	2.2	91	0.8
Golden Redhorse	0	0.0	32	1.4	46	1.1	78	0.7
Rainbow Smelt	1	<0.1	0	0.0	71	1.7	72	0.6
Johnny Darter	61	1.1	0	0.0	0	0.0	61	0.5
Longnose Dace	60	1.1	0	0.0	0	0.0	60	0.5
Emerald Shiner	25	0.5	0	0.0	0	0.0	25	0.2
Stone Cat	0	0.0	7	0.3	6	0.1	13	0.1
Carp	1	<0.1	2	0.1	7	0.2	10	0.1
Northern Redhorse	0	0.0	2	0.1	8	0.2	10	0.1
Common Shiner	10	0.2	0	0.0	0	0.0	10	0.1
Rainbow Trout	0	0.0	0	0.0	8	0.2	8	<0.1
Burbot	0	0.0	4	0.2	3	0.1	7	<0.1
Chinook Salmon	1	<0.1	0	0.0	5	0.1	6	<0.1
Northern Pike	0	0.0	0	0.0	5	0.1	5	<0.1
Banded Killifish	4	<0.1	0	0.0	0	0.0	4	<0.1
Coho Salmon	0	0.0	0	0.1	4	0.1	4	<0.1
Rainbow Darter	4	<0.1	0	0.0	0	0.0	4	<0.1
Freshwater Drum	0	0.1	0	0.0	3	0.0	3	<0.1
Golden Shiner	3	<0.1	0	0.0	0	0.0	3	<0.1
White Bass	0	0.0	0	0.0	2	<0.1	2	<0.1
Pumpkinseed	0	0.0	2	0.1	0	0.1	2	<0.1
Longnose Gar	0	0.0	0	0.0	2	<0.1	2	<0.1
Pink Salmon	0	0.0	0	0.0	1	<0.1	1	<0.1
Splake	0	0.0	0	0.0	1	<0.1	1	<0.1
Lake Sturgeon	0	0.0	0	0.0	1	<0.1	1	<0.1
Bowfin	0	0.0	1	<0.1	0	0.0	1	<0.1
Channel Darter	0	0.0	1	<0.1	0	0.0	1	<0.1
Fantail Darter	1	<0.1	0	0.0	0	0.0	1	<0.1
Slimy Sculpin	1	<0.1	0	0.0	0	0.0	1	<0.1
Mottled Sculpin	1	<0.1	0	0.0	0	0.0	1	<0.1
Northern Redbelly Dace	1	<0.1	0	0.0	0	0.0	1	<0.1
Quillback	0	0.0	0	0.0	1	<0.1	1	<0.1
TOTAL	5 341		2 335		4 198		11 874	
(Number of Taxa)	(25)		(19)		(30)		(48)	

Gill Nets

The overall gill net catch, consisting of 4198 fish, was dominated numerically by alewife (45%). Longnose sucker was second in abundance (18%), followed by white sucker (12%). Other common fish species taken included gizzard shad (5%), lake chub (4%), yellow perch (3%), channel catfish (3%), round whitefish (2%) and yellow pickerel (2%) (Table XXI).

Spatial and Temporal Distribution

Table XXII summarizes the distribution of fish taxa caught by all three fishing methods with respect to the eight locations sampled. Only 647 fish were caught in the Bruce GS 'A' discharge area, and 667 fish netted in MacPherson Bay. BHWP discharge and Douglas Point discharge were associated with larger catches of 864 and 912 fish, respectively. The Gunn Point fish catch was 1206, while that at the Scott Point, Baie du Doré and Sand Bay locations was 1737, 2175 and 3666, respectively. Bruce GS 'A' discharge and MacPherson Bay also recorded low catches during the 1980 aquatic survey, when the catch at MacPherson Bay was the least (Ontario Hydro Research Division Report No 82-182-K).

Alewife was quite common throughout the BNPD sampling area, representing 21% to 48% of the catch at all locations except Sand Bay and Gunn Point (Table XXII). Gill net catch per unit effort (CUE) values for alewife were consistently high during May at all locations except Sand Bay, Douglas Point discharge and Gunn Point, ranging from 95 at Bruce GS 'A' discharge to 336 at Baie du Doré (Figure 14). Alewife catches were generally low during the remainder of the sampling period except for Douglas Point discharge (CUE=162 in June and 161 in August) and BHWP (CUE=140 in July) (Figure 14). Analysis of variance (ANOVA) demonstrated that temporal, but not spatial differences were significant ($p<0.05$) (Appendix 10). Trap net catches of alewife were low (Figure 15) and ANOVA indicated that significant interactions existed ($p<0.05$) suggesting that spatial and temporal trends were not consistent.

The abundance of longnose sucker was highest in gill nets at Sand Bay during July (CUE=140) and in trap nets at Sand Bay during June (CUE=87) (Figures 14 and 15). Catches of this species were low in both gill and trap nets at all locations during August, September and October. ANOVA results resembled those for alewife (Appendix 10).

White sucker catches were highest at Sand Bay and Gunn Point, and exhibited a more homogeneous distribution than longnose sucker or alewife (Table XXII, Figures 14 and 15). ANOVA

TABLE XXII

TOTAL FISH CATCH - BY LOCATION BNPD - 1981

Taxon	Sand Bay		Scott Point		Baie du Doré		Bruce 'A' Discharge		MacPherson Bay		BNPD Discharge		Douglas Point Discharge		Gunn Point	
	No	Per Cent	No	Per Cent	No	Per Cent	No	Per Cent	No	Per Cent	No	Per Cent	No	Per Cent	No	Per Cent
Spottail Shiner	2279	62.17	193	11.11	17	0.78	5	0.77	208	31.18	77	8.90	93	10.20	213	17.66
Alewife	218	5.95	458	26.37	750	34.48	137	21.21	185	27.74	354	41.00	434	47.59	150	12.43
Longnose Sucker	431	11.76	165	9.50	22	1.01	65	10.06	110	16.49	87	10.06	91	9.98	346	28.61
Bluntnose Minnow	126	3.44	527	30.34	499	22.94	3	0.46	0	0.00	27	3.12	0	0.00	16	1.33
White Sucker	205	5.59	96	5.53	133	6.11	116	17.96	75	11.24	83	9.59	72	7.89	290	24.03
Gizzard Shad	11	0.30	38	2.19	147	6.76	8	1.24	0	0.00	7	0.81	53	5.81	9	0.75
Brown Bullhead	6	0.16	8	0.46	213	9.79	1	0.15	1	0.15	1	0.12	0	0.00	0	0.00
Sand Shiner	72	1.96	13	0.75	64	2.94	2	0.31	0	0.00	75	8.67	0	0.00	0	0.00
Cyprinidae	205	5.59	7	0.40	0	0.00	5	0.77	0	0.00)	0	0.00	0	0.00	0	0.00
Spotfin Shiner	13	0.35	9	0.52	40	1.84	144	22.29	0	0.00	0	0.00	0	0.00	0	0.00
Rock Bass	2	0.05	25	1.44	124	5.70	29	4.49	3	0.45	8	0.92	0	0.00	5	0.40
Lake Chub	19	0.52	46	2.65	3	0.14	4	0.62	5	0.75	45	5.20	27	2.96	45	3.70
Yellow Perch	25	0.68	20	1.15	34	1.56	7	1.08	11	1.65	5	0.58	14	1.53	35	2.90
Channel Catfish	6	0.16	11	0.63	16	0.74	55	8.51	16	2.40	12	1.39	6	0.66	2	0.17
Smallmouth Bass	11	0.30	26	1.50	21	0.97	4	0.62	2	0.30	21	2.43	13	1.43	9	0.75
Round Whitefish	18	0.49	6	0.35	4	0.18	9	1.39	7	1.05	18	2.08	22	2.41	19	1.57
Yellow Pickerel	3	0.08	5	0.29	7	0.32	33	5.11	16	2.40	13	1.50	8	0.88	6	0.50
Golden Redhorse	3	0.08	15	0.86	31	1.42	6	0.93	7	1.05	4	0.46	7	0.77	5	0.41
Rainbow Smelt	9	0.00	0	0.00	0	0.00	0	0.00	0	0.00	9	1.04	62	6.80	1	0.08
Johnny Darter	0	0.00	36	2.07	18	0.83	0	0.00	1	0.15	6	0.69	0	0.00	0	0.00
Longnose Dace	1	0.03	3	0.17	1	0.05	3	0.46	6	0.90	0	0.00	0	0.00	46	3.81
Emerald Shiner	2	0.05	2	0.12	15	0.69	0	0.00	0	0.00	0	0.00	3	0.33	3	0.25
Stone Cat	3	0.08	7	0.40	1	0.05	0	0.00	0	0.00	1	0.12	0	0.00	1	0.08
Carp	0	0.00	2	0.12	1	0.05	2	0.31	2	0.30	0	0.00	2	0.22	1	0.08
Northern Redhorse	4	0.11	2	0.12	1	0.00	1	0.15	2	0.23	0	0.00	0	0.00	0	0.00
Common Shiner	0	0.00	9	0.52	1	0.05	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Rainbow Trout	0	0.00	0	0.00	2	0.09	3	0.46	3	0.45	0	0.00	0	0.00	0	0.00
Burbot	0	0.00	1	0.06	1	0.05	0	0.00	0	0.00	2	0.23	1	0.11	2	0.17
Chinook Salmon	2	0.05	1	0.06	1	0.05	0	0.00	0	0.00	1	0.12	0	0.00	1	0.08
Northern Pike	0	0.00	0	0.00	5	0.23	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Banded Killifish	0	0.00	2	0.12	1	0.05	0	0.00	0	0.00	1	0.12	0	0.00	0	0.00
Coho Salmon	0	0.00	1	0.06	1	0.05	1	0.15	0	0.00	1	0.12	0	0.00	0	0.00
Rainbow Darter	0	0.00	0	0.00	0	0.00	0	0.00	1	0.15	3	0.35	0	0.00	0	0.00
Freshwater Drum	0	0.00	0	0.00	0	0.00	0	0.00	1	0.15	1	0.1	1	0.11	0	0.00
Golden Shiner	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	0.33	0	0.00
White Bass	0	0.00	0	0.00	0	0.00	1	0.15	1	0.15	0	0.00	0	0.00	0	0.00
Pumpkinseed	0	0.00	0	0.00	0	0.00	2	0.31	0	0.00	0	0.00	0	0.00	0	0.00
Longnose Gar	0	0.00	0	0.00	0	0.00	1	0.15	1	0.15	0	0.00	0	0.00	0	0.00
Pink Salmon	0	0.00	0	0.00	0	0.00	0	0.00	1	0.15	0	0.00	0	0.00	0	0.00
Splake	1	0.03	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Lake Sturgeon	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.08
Bowfin	0	0.00	0	0.00	1	0.05	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Channel Darter	0	0.00	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Fantail Darter	0	0.00	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Slimy Sculpin	0	0.00	0	0.00	0	0.00	0	0.00	1	0.15	0	0.00	0	0.00	0	0.00
Mottled Sculpin	0	0.00	0	0.00	0	0.00	0	0.00	1	0.15	0	0.00	0	0.00	0	0.00
Northern Redbelly Dace	0	0.00	1	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Quillback	0	0.00	0	0.00	0	0.00	0	0.00	1	0.15	0	0.00	0	0.00	0	0.00
TOTAL	3666		1737		2175		647		667		864		912		1206	
(Number of Taxa)	(24)		(32)		(31)		(25)		(27)		(26)		(18)		(22)	

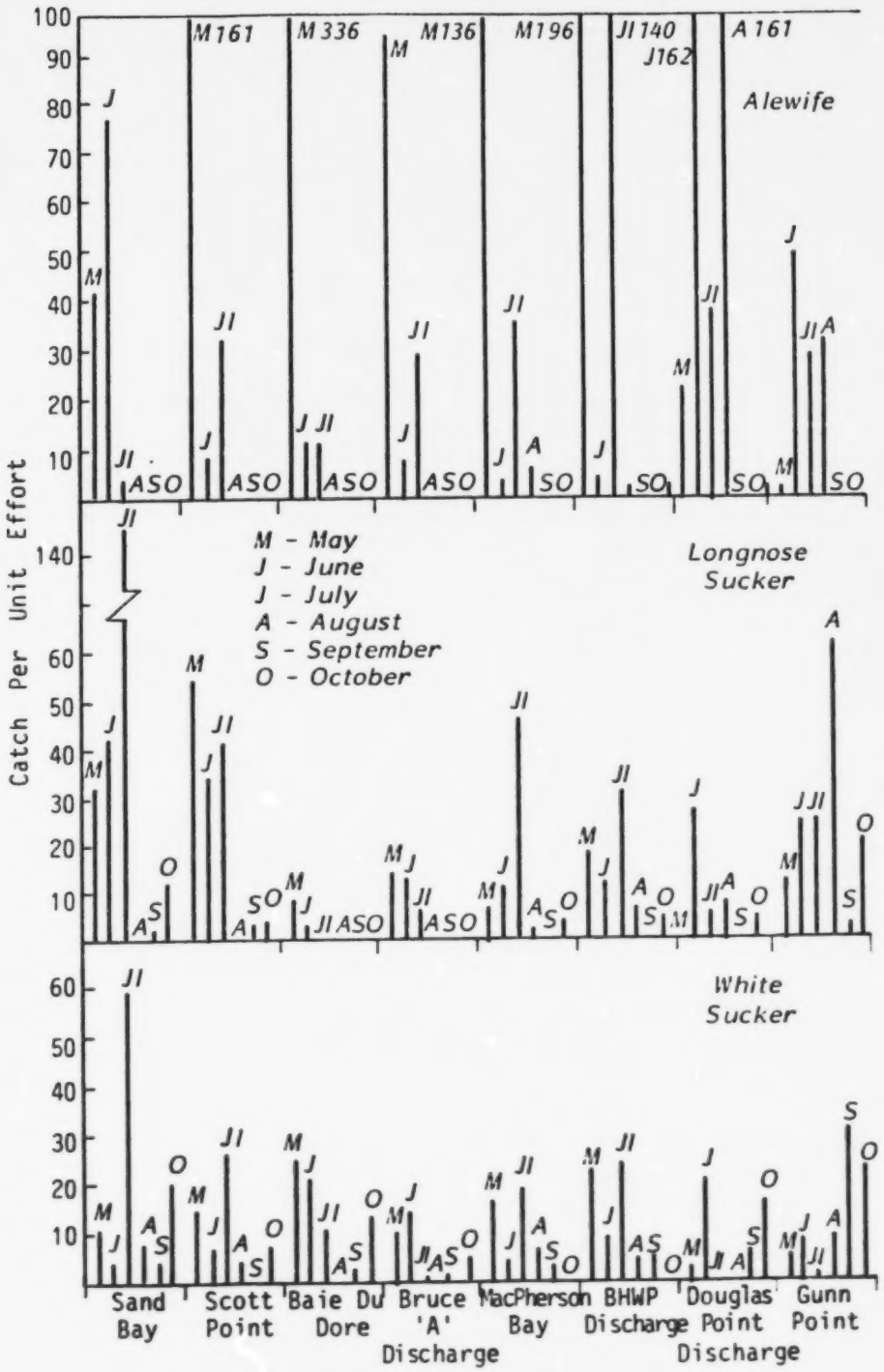

FIGURE 14

SPATIAL AND TEMPORAL CATCH PER UNIT EFFORT OF ALEWIFE, LONGNOSE SUCKER AND WHITE SUCKER CAUGHT BY GILL NET - BNPD, 1981

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indicated that no significant spatial or temporal differences existed for gill net data, however significant spatial and temporal interactions ($p<0.05$) occurred among white sucker trap net catches, a result noted above for alewife and longnose sucker (Appendix 10).

The three most abundant cyprinids, spottail shiner, bluntnose minnow and sand shiner, were largely absent from the discharge locations except for a moderate catch of sand shiner at BHWP discharge in July (Figure 16). These species occurred in highest numbers at either Sand Bay, Scott Point or Baie du Doré in July or August (Figure 16).

The 1981 round whitefish catch (103 fish) (Table XXI) exceeded the catches made in 1979 and 1980 (42 and 54 fish, respectively) (Ontario Hydro Research Division Report Nos 82-107-K and 82-182-K). In 1979 no round whitefish were caught south of Bruce GS 'A' discharge, while catches were made at nearly every location sampled in 1980 and 1981. However the round whitefish catch at Bruce GS 'A' discharge in 1981 was low (9), compared to catches at Sand Bay (18), BHWP discharge (18), Douglas Point discharge (22) and Gunn Point (19).

The distribution of fishes in the nearshore zone off BNPD is probably strongly influenced by the availability of food and spawning sites and by the extent of shoreline exposure. Pelagic fishes such as alewife and gizzard shad frequented the BNPD littoral zone in large numbers during May, June and July, corresponding to their spawning season (Scott and Crossman, 1973). Alewife and gizzard shad concentrations were highest in Baie du Doré where substantial spawning may occur. Although spawning may occur at other locations along the shoreline, the Bruce GS 'A' discharge may not represent a preferred spawning habitat for alewife or gizzard shad. The earlier warming of inshore surface waters at Bruce GS 'A' discharge may influence some migrating alewife to spawn there initially before moving to more northerly sites such as Baie du Doré and Scott Point. Gizzard shad adults and larvae were found predominantly in Baie du Doré indicating that use of the Bruce GS 'A' discharge area for spawning is probably less pronounced for gizzard shad than for alewife.

Few (81) adult smelt were caught in the BNPD nearshore area in 1981, consistent with results of previous aquatic surveys (Ontario Hydro Research Division Report Nos 76-343-K, 77-167-K, 78-395-K, 80-43-K, 82-107-K and 82-182-K). In contrast an abundance of smelt larvae were captured during May (see Ichthoplankton section). It is likely that the inshore movement of spawning smelt occurred prior to the start of adult fish

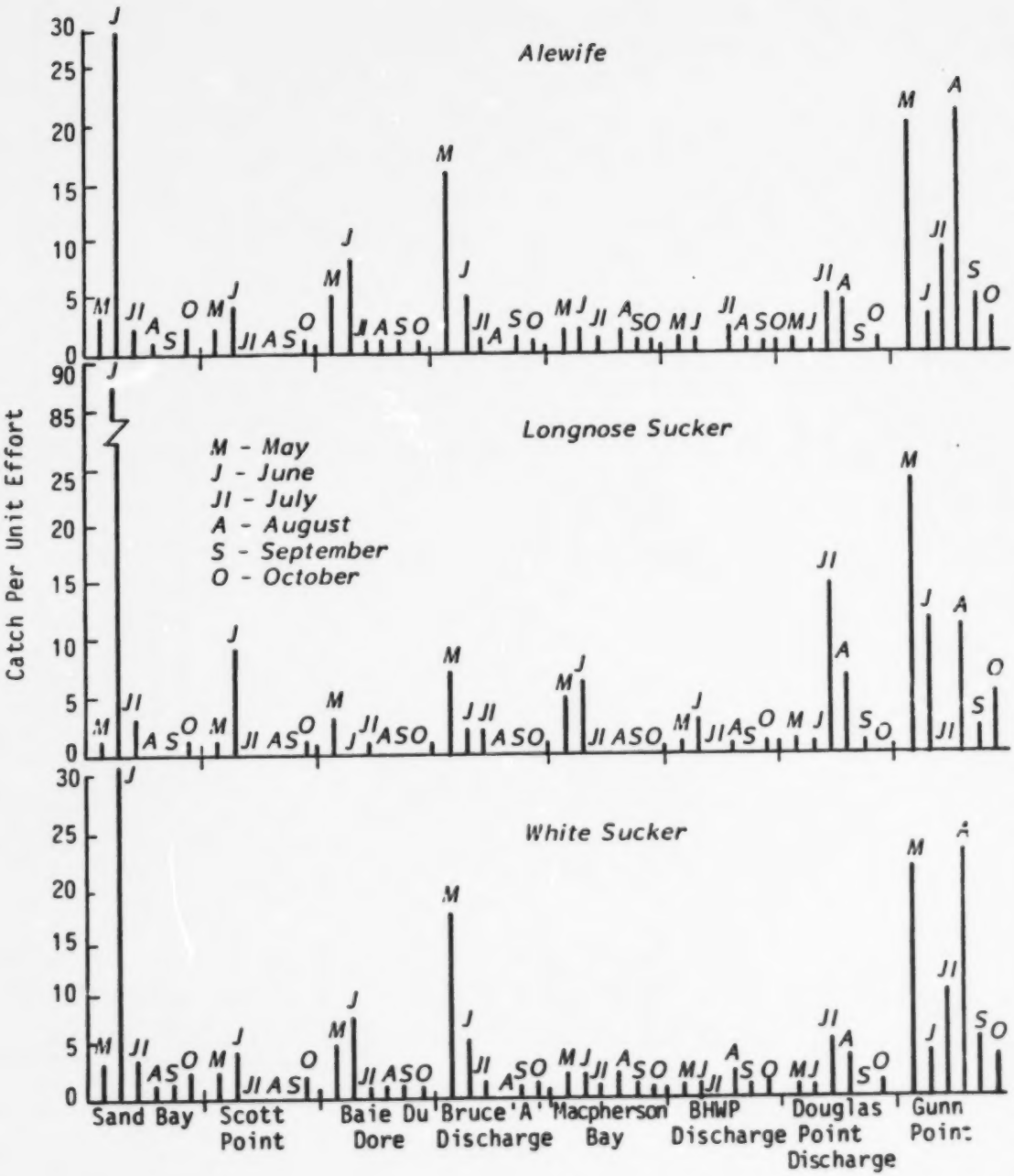

FIGURE 15

SPATIAL AND TEMPORAL CATCH PER UNIT EFFORT OF ALEWIFE, LONGNOSE SUCKER AND WHITE SUCKER CAUGHT BY TRAP NET BNPD - 1981

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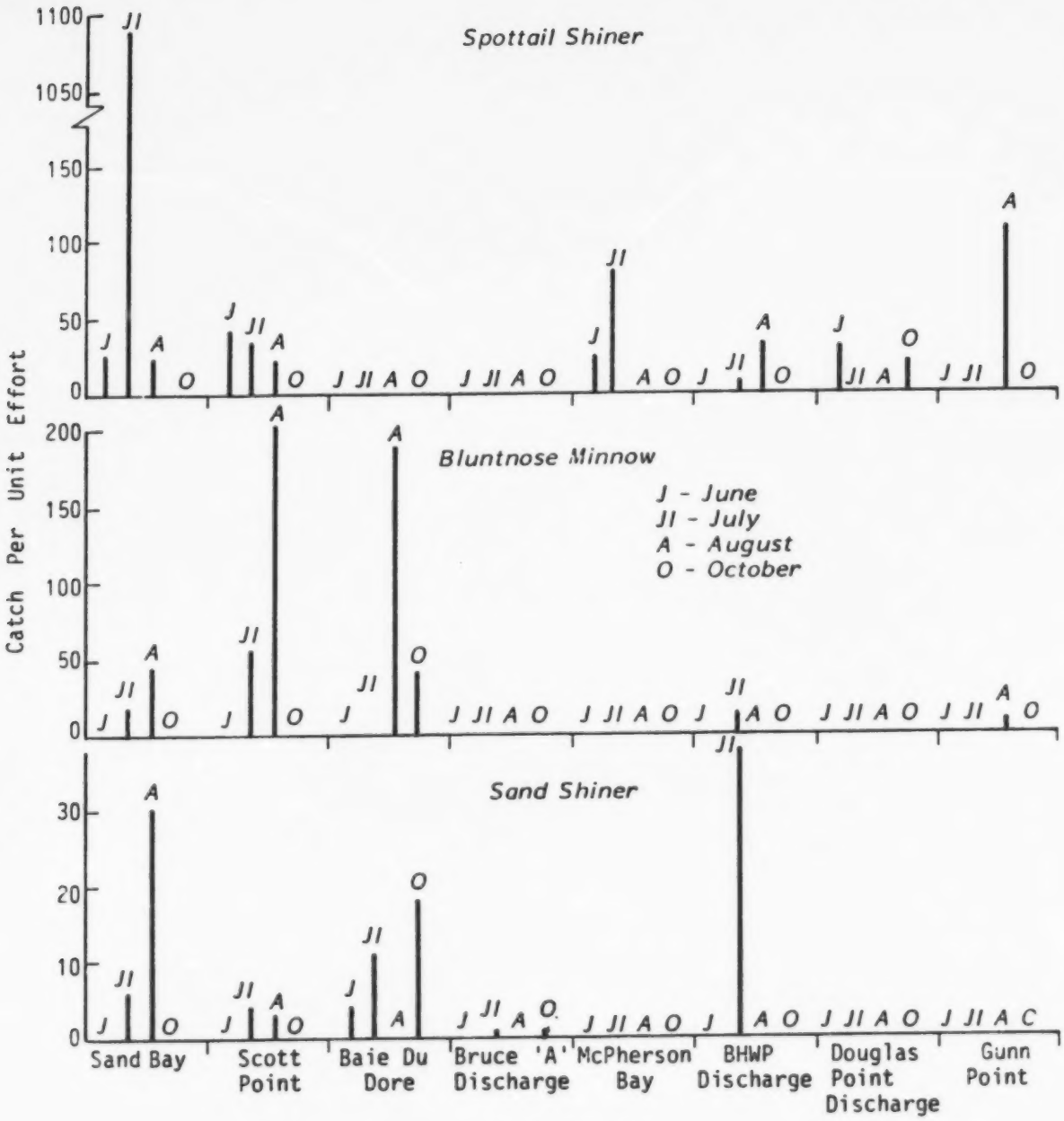

FIGURE 16

SPATIAL AND TEMPORAL CATCH PER UNIT EFFORT OF SPOTTAIL SHINER, BLUNTNOSE MINNOW AND SAND SHINER CAUGHT BY BEACH SEINE - BNPD, 1981

158968-RD

sampling in May, and that the smelt moved quickly offshore after spawning, as noted by other workers (Rupp, 1965; Dahlberg, 1981).

Longnose sucker and minnows were generally more abundant north of Bruce GS 'A' discharge. The distribution of white sucker was more homogeneous along the BNPD shoreline, although highest abundance occurred at Sand Bay, Baie du Doré and Gunn Point. Both longnose sucker and white sucker consumed large proportions (over 90%) of chironomids (Table XXIII), which were quite prominent north of Bruce GS 'A' discharge and at Gunn Point. Consequently bottom-feeding fishes such as suckers and minnows had distributions which often coincided with the distribution of available food resources.

Species such as brown bullhead, rock bass, yellow perch and smallmouth bass occurred in relatively large numbers at Baie du Doré, where a variety of suitable spawning substrates (eg, sand, aquatic vegetation and gravel) are common (Ontario Hydro Research Division Report No 82-107-K). Rock bass are known to spawn mainly in Baie du Doré (Ontario Hydro Research Division Report No 80-45-K) and it is probable that brown bullhead, yellow perch and smallmouth bass spawn there as well. Yellow perch, brown bullhead and rock bass consumed mainly crustaceans of the genus Orconectes, while smallmouth bass fed on leeches and fish (Table XXIII). It is well known that these species consume fair quantities of aquatic insects (Scott and Crossman, 1973), however the present study did not confirm this observation. Therefore it is not possible to comment on the distribution of these fish species relative to the distribution of aquatic insects.

In general, fish captured at BNPD did not concentrate in the Bruce GS 'A' discharge area. However three species, spotfin shiner, channel catfish and yellow pickerel were recorded in highest abundance at Bruce GS 'A' discharge (Table XXII). This occurrence may relate to the requirement for a substantial current for feeding (spotfin shiner and channel catfish) and spawning (yellow pickerel) activities (Scott and Crossman, 1973).

Fish Impingement

During 1981, a total of 48 000 kg of fish were impinged at Bruce GS 'A' (Ontario Hydro Nuclear Generation Division Report No IR-07000-4). Alewife comprised 85% of the total impingement.

Figure 17 compares the monthly catch (in numbers) of alewife taken during experimental fishing with the biomass (kg) of alewife impinged over the same period. The seasonal peak in

TABLE XXIII

FISH STOMACH ANALYSIS DATA, SEPT-1981

Food Item	Fish Species															
	Longnose Sucker (16)		White Sucker (21)		Brown Bullhead (1)		Rock Bass (15)		Smallmouth Bass (1)		Yellow Perch (12)		Yellow Pickerel (1)		Rainbow Trout (1)	
	No (%)	wt (%) (g)	No (%)	wt (%) (g)	No (%)	wt (%) (g)	No (%)	wt (%) (g)	No (%)	wt (%) (g)	No (%)	wt (%) (g)	No (%)	wt (%) (g)	No (%)	wt (%) (g)
Acarina	60(2.05)	0.81(2.22)														
Amnicola spp			1(0.04)	0.07(0.10)												
Amphipoda			6(0.15)	0.25(0.38)												
Asellus spp			2(0.07)	0.10(0.15)												
Bythinia spp			2(0.07)	0.17(0.25)												
Cerapus spp			10(0.37)	0.15(0.23)												
Ceratopogonidae			1(0.04)	0.06(0.10)												
Chironomini	389(13.32)	1.64(4.56)	154(5.65)	1.43(2.16)												
Corixidae			1(0.04)	0.41(0.62)												
Ephemera spp			12(0.44)	0.57(0.85)												
Ephemeroptera							1(8.33)	0.03(0.26)								
Fish Remains								0.63(4.96)		2.71(90.00)		0.52(1.63)				5.09(100.0)
Gammarie pseudellimnaeus			2(0.07)	0.07(0.10)												
Gastropoda			1(0.04)	30.87(46.71)												
Glossiphoniidae									1(100.0)	0.30(10.00)						
Gyraulus spp			38(1.32)	0.45(0.68)												
Hydrilla astaca			63(2.31)	1.01(1.53)												
Lepidoptera spp			2(0.07)	0.05(0.08)												
Limnaea spp			35(1.28)	4.16(6.30)												
Miscellaneous		25.04(68.64)		22.03(33.32)				0.01(0.08)								
Oecomectes proximoue							10(83.33)	12.10(96.69)			20(95.24)	26.36(82.74)				
Oecomectes spp			2(0.07)	0.31(0.48)	1(100.0)	1.19(100.0)	1(8.33)	<0.01(0.02)			1(4.76)	4.98(15.63)				
Orthocladiae	2202(75.41)	8.11(22.23)	1161(42.62)	2.15(3.25)												
Physa spp			5(0.18)	0.46(0.69)												
Polycentropus spp			6(0.22)	0.27(0.41)												
Stenonema spp			1(0.04)	0.03(0.05)												
Tanypodinae	259(8.87)	0.85(2.32)	1223(44.90)													
Tanytarsini	10(0.34)	0.03(0.10)														

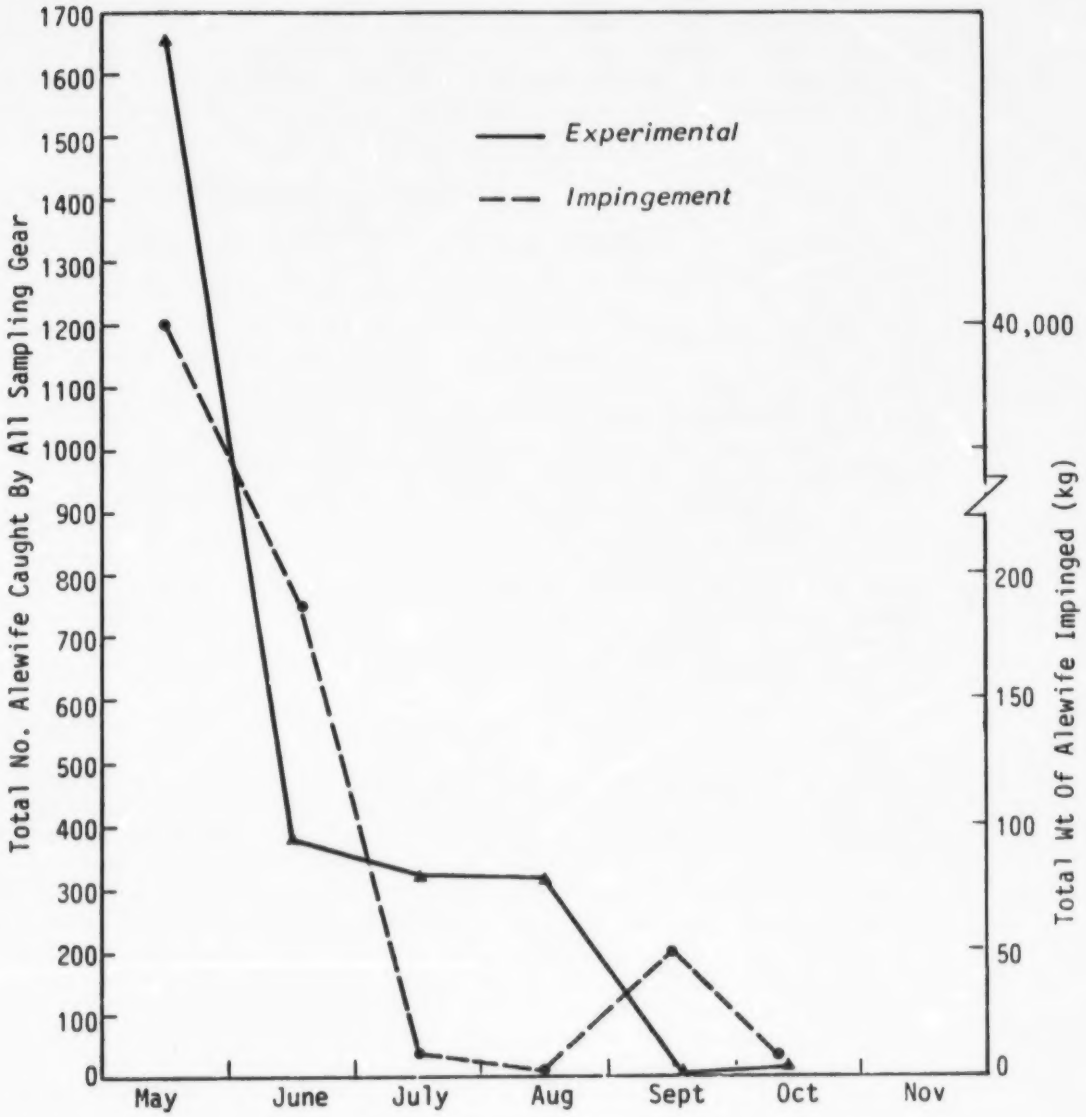

FIGURE 17

COMPARISON OF ALEWIFE CATCHES MADE DURING MAY-OCTOBER BY EXPERIMENTAL FISHING AND BY IMPINGEMENT BNPD, 1981

158969-RD

alewife abundance (May-June) indicated by experimental fishing is reflected in the very high alewife biomass impinged during May. Assuming adult fish captured in May averaged a minimum weight of 30 g (Argyle, 1982), then the number of alewife impinged during May is estimated at 1 333 000 fish. The smaller peak in alewife impingement during September may indicate adult alewife which were returning to deeper water after spawning (Figure 17).

Age Structure of Selected Fish Species

The ages of 16 longnose sucker, 20 white sucker, 15 rock bass, 11 yellow perch and 54 round whitefish were determined in 1981. Longnose sucker and white sucker ranged in age from 5 to 15 years, with most fish between 9 to 13 years (longnose sucker) and 6 to 10 years (white sucker) (Table XXIV).

Rock bass ranged in age from 1 to 5 years with 2 year-old fish having the highest frequency. Five year-old fish had the greatest frequency in the small sample of yellow perch, which had minimum and maximum ages of 2 and 7, respectively (Table XXIV).

Round whitefish ranged in age from 3 to 9 years. The 1974 and 1976 year classes were dominant in the sample, suggesting that year class strength was stronger in those years than in others, if variations in annual mortality are assumed to be small.

3.3.5 Nesting Gulls

A comparison of estimates of the numbers of gull nests at BNPD in 1979, 1980 and 1981 is presented in Table XXV. Although the number of nests counted in 1980 (Ontario Hydro Research Report No 82-182-K) and 1981 fell within the range of the visual estimate made in 1979 (Ontario Hydro Research Report No C79-246-K) there appeared to be about a 19% drop in the number of nests from 1980 (5811 ring-billed gull, 285 herring gull) to 1981 (4673 ring-billed gull and 260 herring gull). This trend is unlike that of the Eastern Headland of Toronto's outer harbour, a man-made spit, where ring-billed gull nests have increased from ten in 1973 to 20 000 in 1977 (Blokpoel and Haymes, 1979) and continued increasing through 1980 (H. Blokpoel, Canadian Wildlife Service - personal communication). The reduction in the number of nests appeared to be from the periphery of the colony. Gulls nesting at the periphery of a colony tend to be younger (Haymes and Blokpoel, 1980) and may be more prone to move to another colony to breed.

TABLE XXIV

AGE STRUCTURE OF SELECTED FISH SPECIES AT BNPD - 1981

Age (Years)	Year Class Except Round Whitefish	Frequency (numbers)					Year Class (Round Whitefish Only)
		Longnose Sucker	White Sucker	Rock Bass	Yellow Perch	Round Whitefish	
1	1980	-	-	1	-	-	-
2	1979	-	-	6	2	-	-
3	1978	-	-	4	1	7	1977
4	1977	-	-	3	1	13	1976
5	1976	1	-	1	4	3	1975
6	1975	1	4	-	2	13	1974
7	1974	-	-	-	1	8	1973
8	1973	-	4	-	-	7	1972
9	1972	2	5	-	-	3	1971
10	1971	3	4	-	-	-	-
11	1970	3	-	-	-	-	-
12	1969	2	2	-	-	-	-
13	1968	2	-	-	-	-	-
14	1967	-	-	-	-	-	-
15	1966	2	1	-	-	-	-

TABLE XXV

NUMBER OF GULL NESTS AT BNPD 1979-1981

	1979		1980		1981	
	Ring-Billed[1]	Herring	Ring-Billed[2]	Herring[2]	Ring-Billed[2]	Herring[2]
Inside Fence			4548	120	3761	87
Outside Fence		141[2]	1263	165	912	173
Total	4000-6000	200-300[1]	5811	285	4673	260

[1] Visual estimate
[2] Nest Count

4.0 SUMMARY

4.1 Physical Characteristics

The maximum rate of inorganic sedimentation for the May to August period was near 3.0 g/cm^2/month at Douglas Point discharge. It is likely that the higher rates of inorganic sedimentation found at Douglas Point discharge and Gunn Point locations were partially attributable to construction activities at the Bruce GS 'B' site. The pattern of deposition of organic material resembled that observed for inorganic material, with the exception that organic sedimentation at the 7 m and 12 m depth contours of Bruce GS 'A'discharge was disproportionately greater than inorganic sedimentation, compared with all other locations.

Mean daily water temperatures were normally higher in Bruce GS 'A' discharge than in Baie du Doré throughout the year. Temperature maxima were 29.7°C for Bruce GS 'A' discharge and 25.7°C for Baie due Doré, recorded on August 13 and 24, respectively. Water temperature fluctuations indicated that a greater range of temperature was experienced at Baie du Doré during winter months. Vertical temperature profiles showed that strong thermal gradients existed during June, July and August, with maximum vertical stratification recorded on August 20 at Sand Bay, September 30 at the 7 m depth contour of Bruce GS 'A' discharge, and July 29 at Macpherson Bay and the 12 m depth contour of Bruce GS 'A' discharge. Isothermal conditions were restored by September 30 at all stations monitored, except at the 7 m depth contour of Bruce GS 'A' discharge where a vertical thermal gradient was evident on October 30, the final sampling date. Secchi depths readings indicated that minimum water transparency (2 m) occurred on September 30 at Bruce GS 'A' discharge, while maximum water transparency (7 m) occurred on August 20 at both Bruce GS 'A' discharge and Macpherson Bay.

4.2 Water Chemistry

The water quality parameters examined generally reflected the oligotrophic nature of Lake Huron. Levels of parameters displayed greater temporal rather than spatial variability. Peaks in the concentrations of nutrient parameters (soluble phosphorous, nitrogen and silica) were observed in May or June. The maximum level of soluble phosphorous at Bruce GS 'A' discharge (9 µg/L) was lower than that noted for other locations. Characteristic bimodal peaks in chlorophyll a concentration were evident at all locations, and mean chlorophyll a concentrations ranged from 1.1 to 1.2 µg/L over the sampling period. Levels of suspended solids tended to be higher in spring and fall, whereas

concentrations of dissolved solids were maximal during mid-summer. Levels of other water quality parameters such as turbidity and pH were typical of Lake Huron.

4.3 Biological Characteristics

4.3.1 Attached Algae

Nineteen taxa of attached algae and three taxa of epiphytic algae were collected from the BNPD shoreline. Temporal changes in species composition occurred, but differed among the sites sampled. Spring dominance by Ulothrix spp was often followed by the prominence of Calothrix later in the year. Bulbochaete sp and Cladophora sp gained prominence at some sites during the summer. The composition of attached algae communities did not change substantially with increasing depth. Analysis of variance indicated that seasonal trends of algal growth, as reflected in biomass estimates, were not uniform across locations sampled.

4.3.2 Benthic Macroinvertebrates

Oligochaetes, dipterans, ephemeropterans, trichopterans and gastropods were the principal taxonomic groups of benthic organisms collected in rock cage samples. A total of 21 988 benthic organisms was collected. The most abundant taxa included the oligochaete Nais pardalis, the ephemeropteran Cladopelma spp, the trichopteran Cheumatopsyche spp and the gastropod Physa gyrina. However, N. pardalis and Cladopelma spp were found almost exclusively at Bruce GS 'A' discharge (3 m depth) on July 2. Baie du Doré was associated with the largest number of benthic invertebrates, and Gunn Point had the least number.

Two main benthic macroinvertebrate distribution patterns were identified. The oligochaetes, eg, Nais pardalis and N. variabilis exhibited greatest abundance south of and including Bruce GS 'A' discharge. Cheumatopsyche spp and other aquatic insects were concentrated mainly in the northern part of the study area, particularly Baie du Doré, as were the most prominent amphipod, Gammarus fasciatus, and the dominant gastropod, Physa gyrina. Highest numbers of benthic organisms were observed inshore along the 3 m depth contour, with abundance generally declining with depth.

Oligochaetes, dipterans and Acarina dominated in vacuum dome samples. Nais pardalis and Pseudosmithia spp were prominent taxa. Benthic organisms occurred in high density at Bruce GS 'A' discharge, Baie du Doré and Transect L, with the highest overall mean density (all taxa combined) reaching 2 976 organisms/m^2 in Baie du Doré. Overall the greatest mean density

of benthic organisms was found along the 7 m depth contour, although Nais pardalis was heavily concentrated at the 3 m depth contour of Bruce GS 'A' discharge and Baie du Doré.

Diversity indices did not show any consistent distribution patterns among benthic organisms collected in rock cages or vacuum domes. Mutual Information Analysis revealed four zoobenthic assemblages among vacuum dome samples and seven assemblages among rock cage collections, reflecting the greater number of taxa collected by the latter sampling method. The pattern of distribution of zoobenthic assemblages was similar for both rock cage and vacuum dome collections. Assemblages containing greater proportions of aquatic insects and amphipods were more prevalent at northerly locations (Sand Bay to Baie du Doré), whereas assemblages dominated by oligochaetes were generally more prominent from Bruce GS 'A" discharge southward to Gunn Point. The most noticeable exception to this distribution pattern was the occurrence of an assemblage with large numbers of dipterans at Gunn Point, as indicated by August vacuum dome samples. The concentration of oligochaetes in discharge areas, particularly Bruce GS 'A' discharge, may be associated with elevated discharge temperatures and strong current activity.

4.3.3 Fish

Alewife, smelt and carp comprised the bulk of the overall larval fish catch. Very few fish eggs were collected. Smelt larvae were most abundant during May, and had a mean total length of about 6.0 mm. Numbers of smelt larvae declined during July and August. Alewife larval abundance peaked in July at a mean total length of 5.3 mm.

Both smelt and alewife larvae were frequently caught inshore at the 1 m and 3 m depth contours in large numbers. However, the data suggested that larger smelt larvae may move directly into deeper strata while young-of-the-year alewife may remain inshore in sheltered areas such as Baie du Doré. A higher abundance and number of larval fish species occurred during the 1981 aquatic survey compared with the 1979 survey, and is attributed largely to the addition of 1 m depth contour sampling locations in the 1981 survey. Estimates of daily larval smelt entrainment ranged from a mean of 1.8×10^4/day at Douglas Point GS to a mean of 2.9×10^6/day at Bruce GS 'A' during May. Maximum larval smelt entrainment occurred in June when a mean of 2.9×10^6 larvae were entrained per day.

A total of 11 874 adult and juvenile fish representing 48 taxa was caugnt near BNPD in 1981. Numerically abundant fish species were spottail shiner, alewife, longnose sucker, bluntnose minnow

and white sucker. Fish species of commercial or recreational importance were captured in low numbers and collectively accounted for about 4% of the total catch. Spottail shiner dominated the beach seine catch, while alewife was the most abundant fish species taken in gill and trap nets.

Bruce GS 'A' discharge and Macpherson Bay were associated with the lowest overall fish catches of all sampling locations (647 and 667 fish, respectively). Catches of spotfin shiner, channel catfish and yellow pickerel were highest in the Bruce GS 'A' discharge and may indicate a preference for high current areas. Maximum catches of spottail shiner, longnose sucker and white sucker were recorded at Sand Bay. Catch per unit effort data demonstrated that higher alewife and longnose sucker catches occurred during the spring in gill nets, and that temporal and locational trends in trap net catches were not uniform. White sucker demonstrated a more homogeneous distribution than longnose sucker or alewife. The distribution of bottom-feeding fish (suckers and minnows) often coincided with distributions of food sources such as aquatic insects. Stomach contents of longnose and white sucker consisted principally of chironomids. Baie du Doré was frequented by relatively large numbers of rock bass, yellow perch, smallmouth bass and brown bullhead.

4.3.4 Nesting Gulls

Gull nests totalled 4 933 during the 1981 survey, and were less than those observed during 1980 (6,096).

Approved:

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Chemical Research Dept

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Biological Research Section

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APPENDIX I

VERTICAL TEMPERATURE PROFILES AND SECCHI DEPTH READINGS TAKEN AT BNPD-1981

	Sand Bay 12 m						Scott Point 12 m						Bruce 'A' Discharge 7 m						Bruce 'A' Discharge 12 m					
	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30
S	9.3	12.5	13.2	15.7	15.0	8.2	10.0	11.0	11.1	16.7	17.0	Not Taken	14.0	15.0	10.0	16.4	21.4	13.5	8.4	13.5	15.0	12.9	15.8	10.4
1	9.3	12.5	13.0	9.7	15.0	8.2	10.0	11.0	11.1	13.2	17.7	"	13.0	14.5	9.8	15.5	20.1	12.6	8.4	15.0	12.1	10.1	15.7	10.1
2	9.2	12.5	12.6	9.4	15.0	8.2	9.8	11.0	11.1	11.6	16.7*	"	11.5	14.0	9.6	14.1	16.3*	12.0	8.4	14.0	11.4	9.9	15.6*	10.2
3	7.6	12.0	11.9	9.2	15.0	8.2	9.8*	11.0	11.0	10.4	15.0	"	11.0*	13.5	8.5	13.6	15.2	10.4	8.2	13.0	11.2*	9.2	15.4	10.1
4	7.2*	12.0	11.4	8.4	15.0*	8.2*	9.8	11.0	10.9	9.3	14.6	"	10.7	12.0	7.2	13.0	15.2	9.6	8.0*	11.5	11.0	8.9	15.1	10.0*
5	7.0	12.0	10.0*	8.1	15.0	8.2	9.8	11.0	10.5*	8.1	14.6	"	10.5	12.0*	7.1	12.8	15.2	9.6*	7.8	11.5	8.4	8.7	15.0	9.9
6	6.9	12.0*	10.8	8.1*	15.0	8.3	9.8	11.0*	10.0	7.9	14.4	"	10.5	12.0	7.1	12.6	15.2	9.6	6.7	11.5*	7.9	8.2	14.6	9.8
7	6.8	12.0	10.6	8.1	15.0	8.3	9.8	10.5	8.3	7.9*	13.9	"	10.5	12.0	7.2	12.6*	15.2	9.6	6.2	11.5	7.6	7.8*	14.7	9.7
8	6.7	12.0	9.6	8.1	15.0	8.3	9.6	10.5	8.0	7.9	13.9	"	10.4						6.0	11.5	7.5	7.7	14.6	9.5
9	6.7	12.0	9.0	8.1	15.0	8.3	91.5	10.5	7.9	7.9	13.9	"							6.0	11.5	7.4	7.6	14.6	9.5
10	6.6	11.5	9.1	8.1	15.0	8.3		10.5	7.9	7.9	13.9	"							6.0	11.5	7.4	7.6	14.5	9.5
11		11.0	9.2	8.2	15.0	8.3		11.0	7.9	7.9	13.9	"							5.9	11.5	7.4	7.6	14.5	9.5
12		11.0	9.1	8.4	15.0	8.3		11.0			13.9	"							5.9	11.5	7.4	7.5	14.5	9.5

	Bruce 'A' Intake 12 m						MacPherson Bay 12 m						BNPP Discharge 12 m						Douglas Point 12 m						Gunn Point 12 m					
	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30	May 28	June 25	July 29	Aug 20	Sept 30	Oct 30
S	8.5	18.5	12.2	14.6	15.5	9.5	8.5	18.5	13.4	14.6	15.5	9.4	10.0	18.5	10.2	14.8	17.4	10.6	7.0	18.5	12.5	15.2	15.4	10.7	6.9	20.5	11.2	15.4	15.3	9.4
1	8.0	18.5	9.1	14.1	15.5	9.5	8.0	18.5	9.8	14.1	15.5	9.4	10.0	18.5	7.3	14.6	16.8	10.1	7.0	18.5	7.4	14.4	15.4	10.1	6.9	20.2	8.5	15.2	15.3	9.3
2	8.0	17.5	8.3	13.7	15.5*	9.5	8.0	17.0	7.7	13.4	15.5	9.4	9.0	16.5	6.6	14.4	15.8	9.6	6.5	17.5	6.8*	13.8	15.4	9.8	6.7	20.2	7.2	14.9	15.3	9.3
3	8.0	16.5	7.9	13.4	15.5	9.5	8.0*	16.0	7.6	13.3	15.5*	9.3	8.5*	16.5	6.3*	13.3	15.5*	9.6	6.2*	16.0	6.6	13.5	15.4*	9.7	6.5*	20.0	6.7	14.1	15.2*	9.1
4	7.5*	14.5	7.3	12.9	15.5	9.5	7.5	14.5	7.5*	13.0	15.5	9.3	7.0	13.5	6.5	13.2	15.4	9.6*	6.0	14.0	6.5	13.2	15.4	9.6	6.3	20.0	6.6*	13.9	15.3	9.2
5	7.5	12.0*	7.0*	11.3	15.5	9.5	7.5	14.5*	7.2	12.9	15.5	9.3	7.0	13.0	6.2	12.9*	15.4	9.3*	6.0	13.5*	6.3	11.9	15.4	9.6	6.2	20.0	6.4	13.8	15.3	9.2
6	7.0	11.0	6.7	11.1	15.5	9.5*	7.0	12.5	6.4	11.1	15.5	9.3*	7.0	12.0*	6.2	12.6	15.4	9.3	6.0	12.5	6.1	10.1*	15.4	9.5*	5.9	20.0*	6.3	13.6*	15.3	9.2*
7	6.5	10.0	6.5	10.9*	15.4	9.4	6.5	11.0	6.4	10.2*	15.4	9.3	6.0	11.5	6.2	12.3	15.4	9.3	6.0	12.0	6.0	10.0	15.4	9.3	5.7	20.0	6.2	12.2	15.3	9.2
8	6.5	9.5	6.5	10.7	15.3	9.4	6.5	10.5	6.4	10.0	15.4	9.3	6.0	11.5	6.2	10.3	15.4	9.2	6.0	11.0	6.0	9.9	15.4	9.2	5.7	20.0	6.1	10.6	15.3	9.1
9	6.5	9.0	6.5	10.5	15.3	9.4	6.5	9.5	6.4	9.9	15.4	9.3	6.0	11.0	61.2	9.7	15.4	9.2	5.5	10.5	5.9	9.4	15.4	9.1	5.7	20.0	6.0	9.4	15.2	9.1
10	6.5	9.0	6.5	10.3	15.3	9.3	6.5	9.5	6.4	9.9	15.4	9.3	6.0	10.0	6.3	9.5	15.4	9.0	5.5	10.5	5.9	9.2	15.4	9.1	5.7	20.0	5.6	8.4	15.0	9.1
11	6.5	9.0	6.5	10.0	15.3	9.3	6.5	9.5	6.4	9.7	15.4	9.2	6.0	10.0	6.3	9.0	15.4	8.9	5.5	10.0	5.9	8.9	15.4	9.1	5.6	20.0	5.6	8.4	14.8	9.0
12	6.5	9.0	6.5	7.4	15.3	9.3	6.5	9.5	6.4	9.5	15.4	9.2	6.0	10.0	6.3	8.9	15.4	8.9	5.5	10.0	5.9	8.8	15.4	9.0	5.5	20.0	5.7	8.4	14.8	9.0

* Secchi disk readings noted with asterisk.

APPENDIX 2

VALUES OF SEDIMENTATION DURING THE MAY-AUGUST PERIOD, BNPD-1981

Location	Depth Contour (m)	Mean Inorganic Weight As g/cm² *(rate: g/cm²/month)	Mean Organic Weight As g/cm² *(rate: g/cm²/month)	Total Material Sedimented As g/cm² *(rate: g/cm² month)
Sand Bay	3	a	a	a
	7	0.4101 (0.1367)	0.0357 (0.0119)	0.4458 (0.1486)
	12	0.0997 (0.0332)	0.0142 (0.0047)	0.1139 (0.0379)
Scott Point	3	0.0997 (0.0352)	0.0142 (0.005)	0.1139 (0.0402)
	7	1.3750 (0.4583)	0.0402 (0.0142)	1.5056 (0.5314)
	12	0.3415 (0.1205)	0.0402 (0.0142)	0.3817 (0.1367)
Baie du Dore	(C) 3	1.0352 (0.4853)	0.0819 (0.0384)	1.1171 (0.5236)
	(D) 3	0.9945 (0.4662)	0.0767 (0.0359)	1.0712 (0.5021)
	(E) 3	Samples Lost		
Bruce 'A' Discharge	3	0.9616 (0.3316)	0.0736 (0.0254)	1.0352 (0.3570)
	7	5.0461 (0.0557)	0.4818 (0.1588)	5.5479 (1.8289)
	12	0.2836 (0.0935)	0.0226 (0.0745)	0.3063 (0.1009)
Bruce 'A' Intake	3	0.1800 (0.0628)	0.0166 (0.0055)	0.1965 (0.0648)
	7	0.8226 (0.2869)	0.0638 (0.021)	0.8864 (0.2922)
	12	0.5377 (0.18)	0.0456 (0.015)	0.5833 (0.1923)
MacPherson Bay	3	1.8315 (0.639)	0.2845 (0.094)	2.1161 (0.7382)
	7	1.1135 (0.18076)	0.0757 (0.0141)	0.5610 (0.1849)
	12	0.5182 (0.18076)	0.0428 (0.0141)	0.5610 (0.1849)
BNMP Discharge	3	0.7051 (0.2460)	0.0675 (0.0235)	0.7725 (0.2695)
	7	0.5625 (0.1856)	0.0455 (0.0150)	0.6080 (0.2006)
	12	0.6476 (0.2135)	0.0536 (0.0177)	0.7012 (0.2312)
Douglas Point	3	5.6898 (2.8449)	0.6071 (0.3036)	6.2969 (3.1485)
	7	6.0171 (3.0086)	0.5924 (0.2962)	6.6095 (3.3048)
	12	6.2078 (3.1039)	0.4143 (0.2072)	6.6221 (3.3110)
Gunn Point	3	3.9749 (1.9875)	0.3892 (0.1946)	4.3641 (2.1820)
	7	3.3361 (1.6680)	0.3287 (0.1644)	3.6648 (1.8324)
	12	0.5359 (0.2679)	0.0985 (0.0493)	0.6344 (0.3172)

* Number in brackets indicates rate per 30 day month.

a Samples invalid

APPENDIX 3

ASH FREE DRY WEIGHTS (g/m^2) OF SHORELINE ATTACHED ALGAL SAMPLES, BNPD-1981

Location	May	June	July	August	September	October
Sand Bay	29.4 25.6 6.0	3.6* 3.3* 9.6	5.6 1.9 5.1	12.8* 8.1 18.5	40.5 51.9 25.2	112.8* 126.9* 77.9*
Transect E	14.3 31.0 5.1	2.1* 15.6* 3.8	33.2 40.5 30.6	6.0* 4.8 12.7	21.2* 20.6* 19.9*	30.1* 53.8* 3.0*
Transect L	10.3 29.5 61.6	14.5* 23.7* 3.7*	29.9 10.8 8.4	7.5 5.8 12.8	44.8* 45.2* 45.9	43.7* 22.0* 40.4*
Scott Point	16.3 11.8 2.4	8.4* 6.3* 4.0	3.6 25.9 10.9	5.6 12.4 7.7	31.4* 33.6* 34.5*	60.1* 8.8* 78.4*
Baie du Doré	59.8* 69.3* 70.4*	135.2* 0.7* 5.7*	4.8 6.6 4.7	13.4 18.0 27.8	40.8* 35.3* 43.7*	59.2* 64.8* 8.4*
Bruce 'A' Discharge	52.0 18.6 28.2	4.7* 2.8* 0.2	4.9 6.3 44.1	23.1 22.3 24.0	52.0* 45.5* 39.2*	46.0 90.0 74.8
MacPherson Bay	7.3 21.3 22.6	1.6* 1.2 6.8	24.0 33.3 29.8	2.7 0.9 0.9	6.9* 7.7* 52.7*	45.1 22.7 20.0
BNWP Discharge	1.7 1.6 6.8	20.3* 73.5 46.4	6.6 63.8 8.9	40.4 20.8 21.4	17.6 27.6 18.0	12.7 108.5 39.3
Douglas Point	11.9 10.6 18.2	0.9* 3.0 1.4	2.9 7.6 3.8	9.9 23.6 7.1	11.6* 10.9* 5.5*	6.3 4.8 35.4
Gunn Point	7.4 24.1 7.2	3.0* 0.5* 3.8	1.4 1.4 1.1	0.0 0.0 0.0	11.2 10.2 33.4	7.6* 16.6* 4.5*

* Identifies samples consisting mainly or entirely of detritus.

APPENDIX 4

ASH FREE DRY WEIGHTS (g/m^2) OF ATTACHED ALGAL SAMPLES FROM DIFFERENT DEPTH CONTOURS BNPD-1981

Location	June	August	October
Gunn Point 1 m	36.4* 1.0* 6.3*	0.0 0.0 0.0	1.4* 2.0* 2.1*
Gunn Point 3 m	4.8* 10.1* 5.6*	9.3 12.4 7.6	1.2* 1.8* 1.7*
Gunn Point 7 m	40.0* 26.7* 31.4*	39.8 26.3 50.0	27.9* 24.6* 26.6*
Gunn Point 12 m	15.3* 14.6* 6.3*	24.6 23.8 14.9	6.6* 7.6* 2.2*
Baie du Doré 3 m	24.1* 116.6* 52.1	28.1* 57.7 -	32.8* 22.4* 21.7
Sand Bay 3 m	80.2* 39.3* 73.9*	6.9 11.3 7.6	13.0* 7.0* 17.2*

* Identifies samples consisting mainly or entirely of detritus.

- Indicates missing samples.

APPENDIX 6

SEASONAL ABUNDANCE AND COMPOSITION OF PRINCIPAL LARVAL FISH SPECIES CAUGHT AT BNPD-1981

Sampling Date		Smelt	Alewife	Carp	Others	Total
April	14	-	-	-	-	-
	29	-	-	-	2	2
May	14	652	-	-	49	701
	20	678	-	-	13	691
	28	30	-	3	60	93
June	10	124	-	126	77	327
	24	6	111	-	71	188
July	7	5	2166	943	325	3439
	22	8	276	-	17	301
August	7	-	-	-	1	1
	20	9	126	-	18	153
					GRAND TOTAL =	5896

APPENDIX 7

MEAN TOTAL LENGTHS (mm ± sd) OF LARVAL SMELT, ALEWIFE AND CARP BNPD-1981

Species	April		May		June		July		August	
	14	29	14	28	10	24	07	22	07	20
Smelt	-	-	6.2	6.0	6.8	7.4	21.0	26.9	-	37.4
	-	-	±0.3	±0.4	±1.0	±1.2	±2.5	±7.4	-	±2.8
	-	-	n=304	n=31	n=113	n=6	n=5	n=8	-	n=9
Alewife	-	-	-	-	-	5.0	5.3	16.0	-	23.0
	-	-	-	-	-	±1.0	±1.5	±6.3	-	±4.8
	-	-	-	-	-	n=110	n=310	n=120	-	n=116
Carp	-	-	-	6.2	6.3	-	6.1	-	-	-
	-	-	-	±0.3	±0.3	-	±0.4	-	-	-
	-	-	-	n=3	n=83	-	n=136	-	-	-

APPENDIX 8

VALUES OF LARVAL SMELT, ALEWIFE AND CARP DENSITIES (NUMBER 1000 m^{-3}) RECORDED FROM LAKE TUNS, FOR PEAK ABUNDANCE PERIODS, BNPD-1981

Species		Smelt								Alewife								Carp							
		Transect*								Transect*								Transect*							
Sampling Date	Contour Depth (m)	B	C	D	E	F	G	I	J	B	C	D	E	F	G	I	J	B	C	D	E	F	G	I	J
May 14	1	2070				1050	430	360	1040																
	3	360				430	270	550	770																
	7																								
May 20	1		40			560	390	4780	1940																
	3		130																						
	7																								
June 10	1	20			20	130	70	20	20										10	40	270	40			40
	3	10		10	50	120	20	40	40										10	20	110	520	50		10
	7	130				70	70	150	220									10				590			
June 24	1									20	230	190	320	70	150		40								
	3									10	40	120	130		10	40	10								
	7									40					40	20									
July 7	1									80	360	240	150	6210	5980	4490	130		20		10	3100	6210	240	90
	3									170	330	200	220	520	300	3700	3800	10	10			10	290	170	540
	7									550				120	210	270	150	10				10	40	10	40
July 22	1									40	1080	610	40	30	10	30	10								
	3									110	780	100	110		40	30	-								
	7									10				30	20	30	10								
August 20	1									130		80	160	20	60	40	140								
	3									50	50	250	90		60	10	10								
	7									60					30		30								

* B - Scott Point
C
D - Baie du Doré
E
F - Bruce 'A' Discharge
G - Bruce 'A' Intake
I - BHWP Discharge
J - Douglas Point Discharge

APPENDIX 10

RESULTS OF TWO-WAY ANALYSIS OF VARIANCE FOR MAJOR SPECIES CAPTURED IN GILL AND TRAP NETS, BNPD-1981

Species	Values of Calcualted F Statistic					
	Gill Net			Trap Net		
	Location	Month	Interaction	Location	Month	Interaction
Alewife	$0.60^{**}_{[7,124]}$	$4.64^{*}_{[5,124]}$	-[a]	$2.67^{*}_{[7,124]}$	$6.93^{*}_{[7,124]}$	$2.68^{*}_{[35,124]}$
Longnose Sucker	$1.98^{**}_{[7,124]}$	$2.93^{*}_{[5,124]}$	-[a]	$8.02^{*}_{[7,124]}$	$11.75^{*}_{[5,124]}$	$8.28^{*}_{[35,124]}$
White Sucker	$1.01^{**}_{[7,124]}$	$1.80^{**}_{[5,124]}$	-[a]	$3.08^{*}_{[7,124]}$	$2.39^{*}_{[5,124]}$	$1.57^{*}_{[35,124]}$

* Significant
** Not significant
p <0.05
a Interaction term not relevant because only one replicate available for gill nets.

POOR

QUALITY

ORIGINAL